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MODERN PLASTICS

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AUGUST 1944

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MODERN PLASTICS

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All editorial contents bearing on military subjects have been released for publication by the Armed Services.

MODERN PLASTICS is regularly indexed in the Industrial Arts Index.

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EXECUTIVE and EDITORIAL OFFICES: 122 E. 42nd St., New York 17, N. Y. WASHINGTON 6, D. C., OFFICE: 625 Colorado Bldg., 14th & G Sts. Published the 1st of each month by Modern Plastics, Incorporated. Publication Office, Twentieth and Northampton Sts., Easton, Pa. Subscription price $5.00 per year, $8.00 for 2 years in U. S., its possessions and South America. Canadian subscriptions $5.50 per year, $9.00 for 2 years; all other countries $6.00 per year, $10.00 for 2 years, payable in American money or its equivalent. Price 50¢ per copy. Printed in U. S. A. Entered as second class matter May 28, 1940, at the Post Office at Easton, Pa., under the act of March 3, 1879. Member of the Audit Bureau of Circulations. Back numbers 3 months or more preceding current issues, when available, $1.00 each.

VOLUME 21 AUGUST 1944 NUMBER 12

General Section

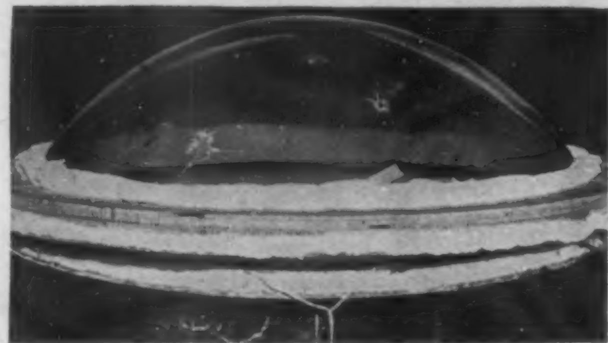
Plastics—Engineering Section

Technical Section

News and Features

ANNOUNCING

Laminated "Lucite"-"Butacite" sheeting for pressurized high altitude flying



DU PONT PLASTICS RESEARCH REPORTS PROGRESS IN IMPROVING TRANSPARENT PLASTICS FOR PRESSURIZED FLYING

PRESSURIZED LAMINATED "LUCITE"-"BUTACITE" enclosure punctured by a bullet from a 50-caliber gun. Inside air temperature of enclosure +50° F., outside air temperature —41° F., internal pressure 5 psi. Size of hole is small enough to retard rate of pressure loss and permit immediate sealing of the hole.

THIS IS ANOTHER VIEW of the laminated dome shown above—after being patched, rotated to a new line of fire, and punctured with another bullet from a 50-caliber gun under the same conditions as described above. Note that the patched area remains intact, in spite of repressurization and the shock of a second bullet.

Here is a Du Pont plastics development which, along with other Du Pont plastics, will have many post-war applications

Progress Report: Problem: Possibility of major rupture—by flak or bullets during pressurized flight at high altitudes, or under excessive aerodynamic pressure at high combat speeds.

Solution: new enclosure formed of a laminate of Du Pont "Lucite" methyl methacrylate resin (two outside sheets) and a single separating interlayer sheet of Du Pont "Butacite" polyvinyl butyral resin.

Advantages: *Self-sealing tendencies*—penetration is confined to the area of the actual point of impact, and the interlayer of "Butacite" tends to seal the hole or confine it to small size even under pressure. Hole easily and quickly patched in flight with prepared disc of "Butacite."

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Light weight—its specific gravity is less per square foot than solid acrylic sheeting which is of equal thickness.

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Laminated by: safety glass companies. *Formed by:* fabricators and airplane companies.

Development work and unlaminated sheet stock by: E. I. du Pont de Nemours & Co. (Inc.), Plastics Department, Arlington, N. J. Address inquiries to Du Pont in Arlington, or in Canada, to Canadian Industries, Ltd., Box 10, Montreal.

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C no oblique components to complicate radial and thrust pressures.

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But there are other items, both parts and complete products, *for which plastics of one kind or another are the perfect answer.*

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Precision Plastics Company offers an experienced and complete molding service, from creative design, if desired, through to delivery of the finished piece. While we are busy now with vital war work, help with the *planning* of your post-war plastics is available right now.

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That seems easy enough—until you see how production influences design, here at Kurz-Kasch.

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Cast into dies, Ethyl Cellulose shapes metal under crushing pressure.

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High in light transmission, Acetate is used for aircraft cowling.

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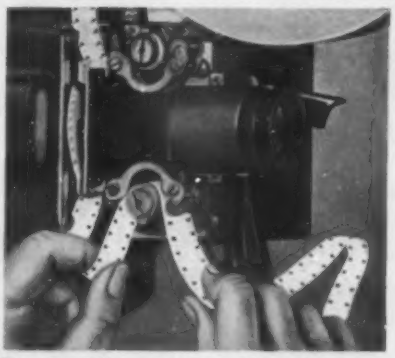
Clarity of cellulose plastics is imperative in X-ray and other film.

CELLULOSE PLASTICS ARE *FLEXIBLE!*



For flexibility (and toughness) movie film is made of Acetate or Nitrate.

Wire insulation of extruded Ethyl Cellulose is highly flexible, extremely tough.

Flexible bristles for paint brushes are now made with Cellulose Acetate.

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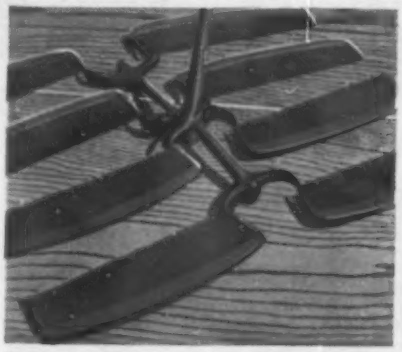

Multiple units, at high speed, result in very low production costs.

Economical one-shot injection molding produces this intricate telephone base.

No waste with cellulose plastics. Every bit of scrap can be re-used.

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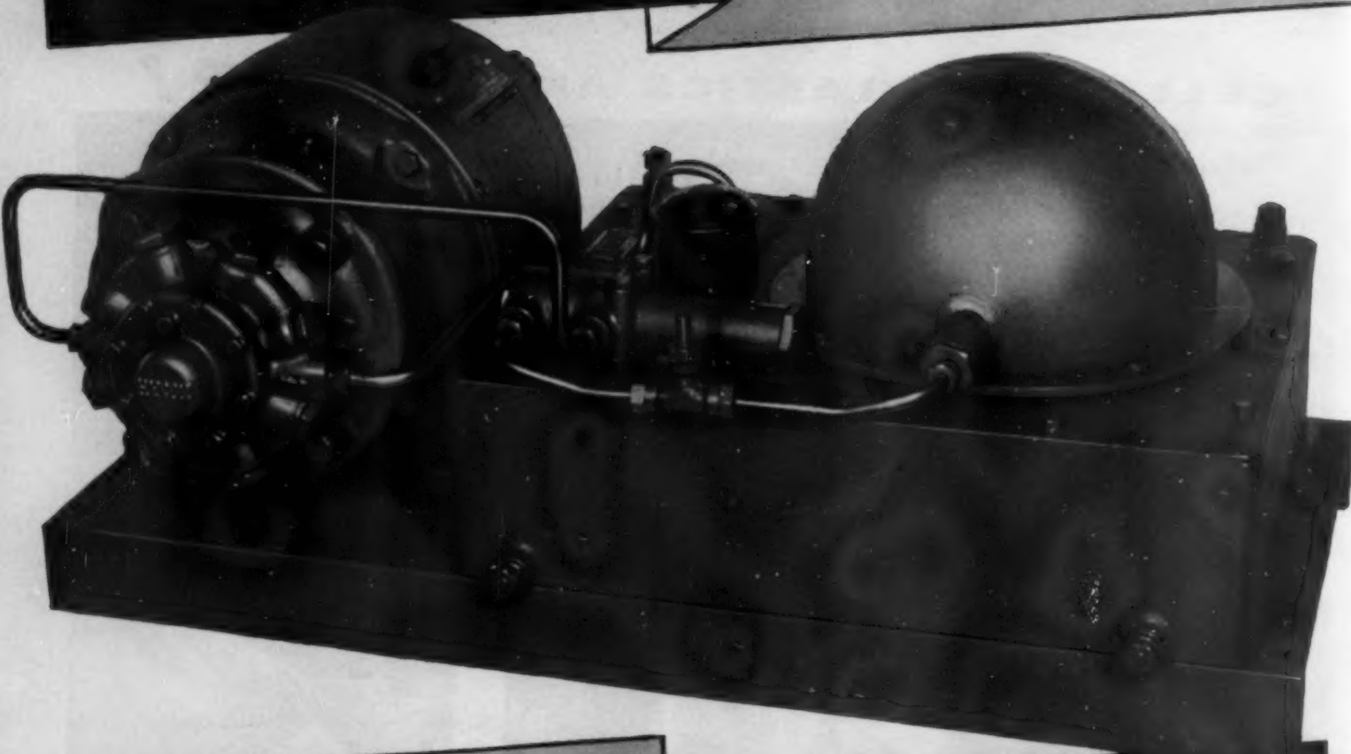

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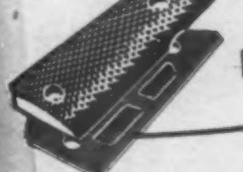
PROBLEM:

BOWL

Must have lustrous finish and wide range of permanent colors, both impervious to rough handling, heat and liquids.



PISTOL GRIPS-

Expansion co-efficient must be suitable for close tolerance with metal. Usefulness must not be impaired by heavy blows, moisture, or oil.

SOLUTION:

KYS-ITE

—the long-fibred wood pulp-filled synthetic resin plastic, preformed before curing.

Versatile is one word for Kysite. Successful is another. This remarkable thermo-setting plastic is doing a real job for essential industries today, and its performance has earned Kysite its place on today's specification sheets for tomorrow's products. Here are some of the reasons.

SHAPES for Kysite forms can be simple or intricate; can incorporate permanent metal inserts. Preforming before curing insures dimensional stability and saves production, machining, finishing and assembly operations.

PRACTICAL and varied in application because of its dielectric and non-reverberating properties, impact strength (4 to 5 times greater than ordinary plastics), effectiveness under wide temperature variations, and resilient strength.

ATTRACTIVE and light in weight Kysite comes in many rich, beautiful colors and lustrous finish; is unaffected by boiling water, mild acid solutions, grease and alcohol.

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AIRTRONICS Preheaters SLASH

CLOSING TIME BY 80%
CURING TIME BY 50%

The Model C B AIRTRONICS preheater is shown at the right. Five of these units are now in use by McDonald Manufacturing Co., molders of the Clarke Gun-Handles.

CLARKE GUN – Handle Data

Materials:	*Macerated canvas filled phenolic*
Inserts:	Five threaded, and one button housing
Outside Dimensions:	Length – 6"; Width – 2¼"; Assembled Thickness – 1"- 2"
Weight:	Preform – 7¼ oz.; Finished Product – 6½ oz.

Former Method	Operation	Preheating by Airtronics
1 min.	*Closing Time*	12 sec.
3½ min.	*Curing Time*	1½ min.

Handles for machine gun control-mechanisms are mighty important these days—and when their output can be speeded up by a simple electronic device, it's important news to molders of plastic products. This is particularly true when the *extra production* needed to meet increased delivery schedules was secured *without* making another die nor using another press—but instead was secured by the AIRTRONICS preheating of preforms.

Developed expressly for production molders, AIRTRONICS preheaters are complete and ready for immediate operation when connected to a power supply. The simplified controls, self-contained electrodes, safety devices—and other advanced features—insure dependable operation.

Investigate the many advantages of equipping your plant with AIRTRONICS preheaters. Find out how you can increase production, increase die-life and improve the quality of your molded products.

Send for your copy of new bulletin. Clearly shows the simplified controls, the 35 sq. in. area self-aligning electrodes, the safety devices and other advanced features. Send for your copy today.

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NEW CELESTIAL NAVIGATION INSTRUMENT *made entirely of* **Plexiglas**

The Hagner Celestial Navigation Instrument—constructed entirely of PLEXIGLAS — consists of a miniature of the celestial sphere, with names and precise locations of the 22 navigational stars, and a world globe with all coordinates. It was invented by F. H. Hagner, Position Finder Corporation, P. O. Box No. 361, San Antonio, Texas.

Crystal-clear PLEXIGLAS, widely used for transparent bomber noses and many other war-essential applications, is well adapted to this navigation instrument designed for use on life rafts to permit the determination of approximate positions without involved calculations, nautical almanac, sextant or cómpass.

The instrument is also used as a visual aid in teaching celestial navigation, for movements of the stars can be reproduced exactly as seen from any part of the world's surface.

Strong, tough, practically unbreakable yet light in weight, PLEXIGLAS is permanently transparent, unaffected by aging, weathering or salt water. It is easy to fabricate or mold into almost any shape.

In addition to its excellent optical properties, PLEXIGLAS is a good electrical and thermal insulator.

Why not investigate how PLEXIGLAS can improve the appearance or performance of your own product? Just call the nearest Rohm & Haas office —Philadelphia, Los Angeles, Detroit, Chicago, Cleveland, New York. Canadian Distributors: Hobbs Glass, Ltd., Montreal.

Only Rohm & Haas makes

PLEXIGLAS

CRYSTAL-CLEAR ACRYLIC SHEETS AND MOLDING POWDERS *

*(Formerly CRYSTALITE Molding Powders)

PLEXIGLAS is the trade-mark, Reg. U.S. Pat. Office, for the acrylic resin thermoplastic sheets and molding powders manufactured by Rohm & Haas Company.

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(PATENTS PENDING)

1 The machine is built as a self-contained unit. It operates either manually or automatic single-cycle.

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3 Oil temperature is controlled automatically.

4 The heat is controlled by the temperature of the material.

5 Heating Cylinders are so inexpensive that extras may be carried—saving considerable material when changes of color or material are necessary.

6 The design of the heating cylinder makes possible the operation of this machine at a maximum pressure on material of only 15,000 lbs. per sq. in.

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IF it is within the very wide range of possible, efficient resin applications...

IF it is approached as a specification job...

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Hence—when a resin is scientifically prepared for *one specific application*—job tested—and its production stabilized within extremely close range of variation—resin "problems" are rarely encountered. And ONLY THEN is *uniform performance* certain.

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• An Impregnating Resin for molded Compregwood for Camfield Manufacturing Company, first to meet Army-Navy specifications.

• Improved Fibre-Binding Resin for Owens-Corning Fiberglas, permitting precision control of resiliency or rigidity of final products.

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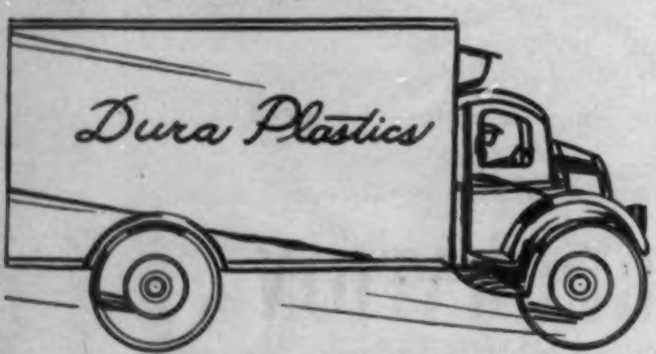
Dura filled the bill

Must get Transparent Plastic Tubes Quickly

Dura offers you transparent acrylic tubes, with our guaranteed **dura** welded seams. Yes, stronger than the material itself, proven by test and actual use. This purchasing agent placed his first order with **dura** when he needed a good tube quickly.



Speedy delivery when promised

Four days later our truck ← was on its way with a major portion of the order. Now our P.A. looks more content, ↑ his worries are over, and he writes us that he cannot understand how we filled his needs so quickly.

What we did for him is not out of the ordinary. We are doing it every day, and can do it for you too. Some of our fabricating assignments include: instrument dial windows and faces, cowlings, shields, tubes, cylinders and numerous other applications requiring light transmission or specific electronic properties. Send your transparent plastic problems to **dura.** No obligation to you, of course.

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Custom fabricating specialists to the aviation, electronic and shipbuilding industries.

Aluminum and Plastics work well as a team

An aluminum ring carries this Plexiglas* navigator's dome, serving as a strong, rigid mount in the plane. A plastic seal makes the assembly secure and weathertight. It's another case of aluminum and plastics working together to handle a difficult assignment well.

By using an extruded aluminum shape for the ring, metal is placed exactly where needed to receive the Plexiglas and its sealing ring. The extrusion method of manufacture supplements aluminum's natural light weight by making certain that there's no excess of metal employed. Formed and welded into a solid circle, production of this aluminum ring goes fast. Costs are moderate.

Wartime products contain a number of similar examples of aluminum and plastic teamwork, each material contributing some desirable property to the finished product. Designers of postwar products are certain to find this combination equally valuable.

Alcoa engineers will gladly give you the benefit of their experience in employing aluminum and plastics jointly. Write ALUMINUM COMPANY OF AMERICA, 2175 Gulf Building, Pittsburgh 19, Pennsylvania.

Registered T. M. of Rohm & Haas Co.

ALCOA ALUMINUM

What's new under the "Main Top"?

"PLASTICS" covers more territory than any other word for a material.

Right now a constantly increasing troupe of ideas and materials are being rehearsed under the "Main Top" for post-war performances that will startle imaginations already excited by the performances of plastics in war service.

The long and vast experience of Owens-Illinois in making containers and creating closures naturally is proving very valuable in the development of plastic packages for post-war use.

Probably new packages for your products are on your list of post-war "musts." When ready to tackle your packaging problems, find out what Owens-Illinois know-how and imagination can create for you in modern plastic containers.

PLASTIC DIVISION OF

OWENS-ILLINOIS GLASS COMPANY

TOLEDO, OHIO

A comparison of SYNTHANE TECHNICAL PLASTICS with certain metals, debunking a popular notion that plastics being "magic" can be used indiscriminately

IT IS CHARACTERISTICALLY HUMAN to back a winner . . . to ascribe precipitately to vitamins or sulfa drugs or plastics more powers and claims than sober research can keep up with. Plastics have their possibilities . . . and their limitations. Good design is the reward of knowing both.

Plastics are doing many jobs that metals used to do, especially since certain critical metal shortages have cropped up. But, basically, plastics are *not* substitute materials. Correctly applied, they should and do stand solely on their own merits.

INTERESTING COMPARISONS TO PROVE the point can be made between our type of plastics—Synthane—and certain metals. Synthane is made by applying heat and pressure to paper or fabric impregnated with thermosetting resins. It is non-metallic, a fact which should at once suggest uses fundamentally different from those of metals. Actually, Synthane is an excellent electrical insulator, and so you find it in hundreds of radio and electrical products and applications, not in place of metal, but to insulate metal. That does not imply Synthane cannot replace metal. As a matter of fact, Synthane has taken over for metals in pulleys, bearings, panels, structural members, scales, dials. The reasons can usually be traced to one or a combination of the many properties of Synthane technical plastics.

ONE OF THE PRINCIPAL REASONS at present is light weight. Synthane has a specific gravity ranging from 1.20 to 1.70, about half that of aluminum, less than magnesium. So in many unstressed parts for aircraft Synthane is a logical consideration.

SYNTHANE LAMINATED PLASTICS GENERALLY have lower mechanical strength than metals for a given cross section. For example, an approximate comparison might read like this:

	Tensile Strength (p.s.i.) ultimate	Compressive Strength (p.s.i.)
Alloyed Aluminum	16,000–60,000	9,000– 47,000 (y)
Brass	40,000–80,000	28,000–126,000 (u)
Cast Iron	16,000–45,000	80,000–200,000 (u)
Synthane	8,000–12,000	30,000– 50,000 (u)

(y—yield strength
u—ultimate strength)

IT IS IMPORTANT, HOWEVER, TO REMEMBER that on a *weight* basis, Synthane may be stronger though redesign of a part for plastics may be necessary.

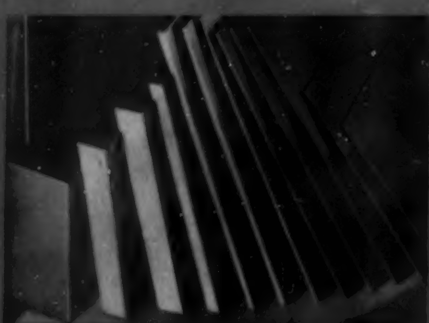
HARDNESS IS A PROPERTY in which another interesting comparison of Synthane with metals can be made. Brinell hardness, tested with 500 Kg. load, 10 mm ball, shows approximately these values: Alloyed aluminum 45–110, Brass 95–150, magnesium (drawn annealed) 29, annealed cast iron 77, Synthane 24–40.

BEHAVIOR UNDER TEMPERATURE CONDITIONS is characteristic of Synthane's non-metallic composition. For instance, whereas the thermal conductivity of aluminum alloys may range from .20 to .54 calories per second per square centimeter per centimeter of thickness per degree C., Synthane's thermal conductivity is about .0005 to .0008. The coefficient of thermal expansion of Synthane is about .0000140 inches per inch per degree F., approximately the same as alloyed aluminum, slightly more than pure aluminum, copper, brass.

CORROSION RESISTANCE IS A SUBJECT of such complications as to temperature, degree of concentration, and type of agent that any comparison with metals would necessarily be lengthy. Synthane does resist corrosion from water, many acids, oils, and salts, and to a greater or lesser extent than metals depending on the metal with which it is compared and the corrosion conditions. Synthane is extensively used as a corrosion resistant material.

APART FROM ITS PHYSICAL, CHEMICAL, electrical and chemical properties, Synthane may be easily and quickly machined by ordinary shop methods, a point which may occasionally influence selection when other factors are the same. And, just as metals are cast for economy in large quantities, so Synthane is available in two molded forms, molded-laminated and molded-macerated, for economy of duplication.

OBVIOUSLY, IN CERTAIN CASES there can be no question of whether to use Synthane plastics or a metal such as when the material must be an electrical conductor or an electrical insulator. In other cases, weight or strength may decide, or corrosion resistance, resilience, hardness, machinability. Or as often happens, the decision may rest upon the extent to which the material required meets many combined specifications. Synthane technical plastics are usually more desired for their combination of properties than for any one specific property for which another specific material or metal may be the only logical answer.



SYNTHANE

PLAN YOUR PRESENT AND FUTURE PRODUCTS WITH SYNTHANE TECHNICAL PLASTICS · SHEETS · RODS · TUBES · FABRICATED PARTS · MOLDED-LAMINATED · MOLDED-MACERATED

SYNTHANE CORPORATION, OAKS, PENNA.

REPRESENTATIVES IN ALL PRINCIPAL CITIES

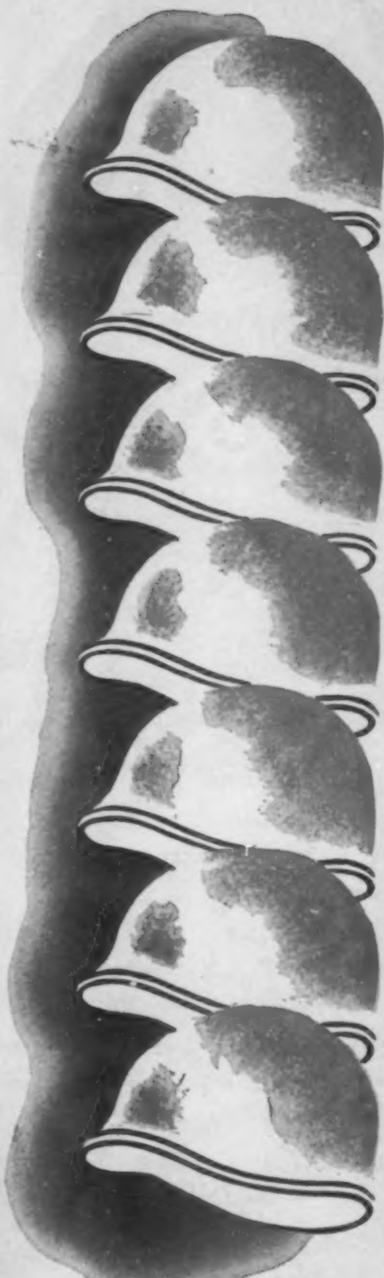
NEW RCI FAST-CURING . . . .

LOW OR HIGH PRESSURE

PHENOLIC LAMINATING VARNISHES

Nos. 5021 and 5022

PLYOPHEN



RCI's versatile line of phenolic laminating resins and varnishes continues to make news.

Now comes khaki-colored No. 5021 Plyophen—and its natural-colored counterpart No. 5022—to speed production of helmet liners, as well as other molded laminates and sheet stock. These plyophens will open the way to quicker production of many other present and postwar products.

With these two Plyophens, curing cycles are exceptionally fast—as rapid as three minutes with sheets .16 of an inch thick. And water resistance and mechanical properties are excellent—in drop tests of helmet liners fabricated with No. 5021 Plyophen and another laminating varnish, the former withstood twice the number of drops.

Add to these properties the fact that these varnishes produce odorless laminates, *and that the water resistance is the same with either high or low* pressure molding—and you can readily vision the wide usefulness of No. 5021 and No. 5022 Plyophen. For complete details of properties and application write direct to the Sales Department.

RCI WORLD-WIDE DISTRIBUTION

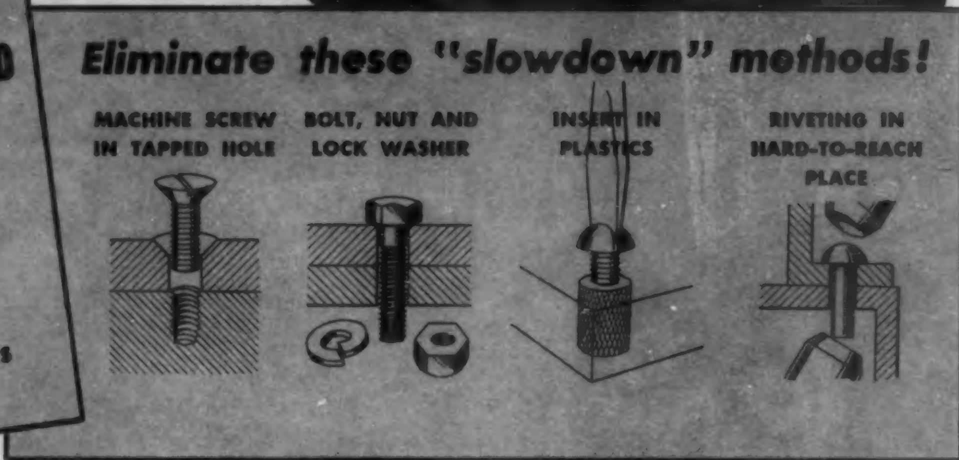
REICHHOLD CHEMICALS, INC.

General Offices and Main Plant, Detroit 20, Michigan

Other plants: Brooklyn, New York • Elizabeth, New Jersey • South San Francisco, California • Tuscaloosa, Alabama • Liverpool, England • Sydney, Australia

SYNTHETIC RESINS • INDUSTRIAL CHEMICALS • CHEMICAL COLORS • INDUSTRIAL PLASTICS

Before you get going on Post-War Production



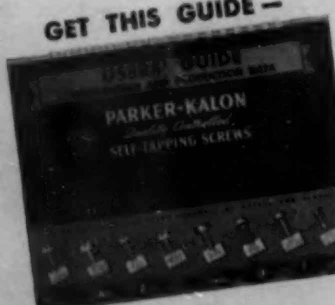
Now is the time to talk to a P-K Assembly Engineer. Before your post-war assembly practices are set-up, have him check all fastenings and point out where you can use the *short-cut method* – P-K Self-tapping Screws – to make savings in time, labor and materials.

One operation makes a fastening with a P-K Self-tapping Screw. You just drive it into a plain untapped hole. You eliminate tapping for machine screws, and tap expense . . . fumbling with bolts and nuts . . . troublesome inserts in plastics . . . riveting in hard-to-reach places. Truly a short-cut to assembly economy!

You'll find the P-K Assembly Engineer's advice unbiased. He'll recommend P-K Screws only when they will save time, lower costs, provide stronger fastenings. And he'll recommend only the best type of Self-tapping Screw for the job, because Parker-Kalon makes *all* types.

No matter what kind of plastic, or metal, you are working with, there's a P-K Self-tapping Screw designed for the job, and you'll find you can adopt it to advantage in 7 out of 10 cases.

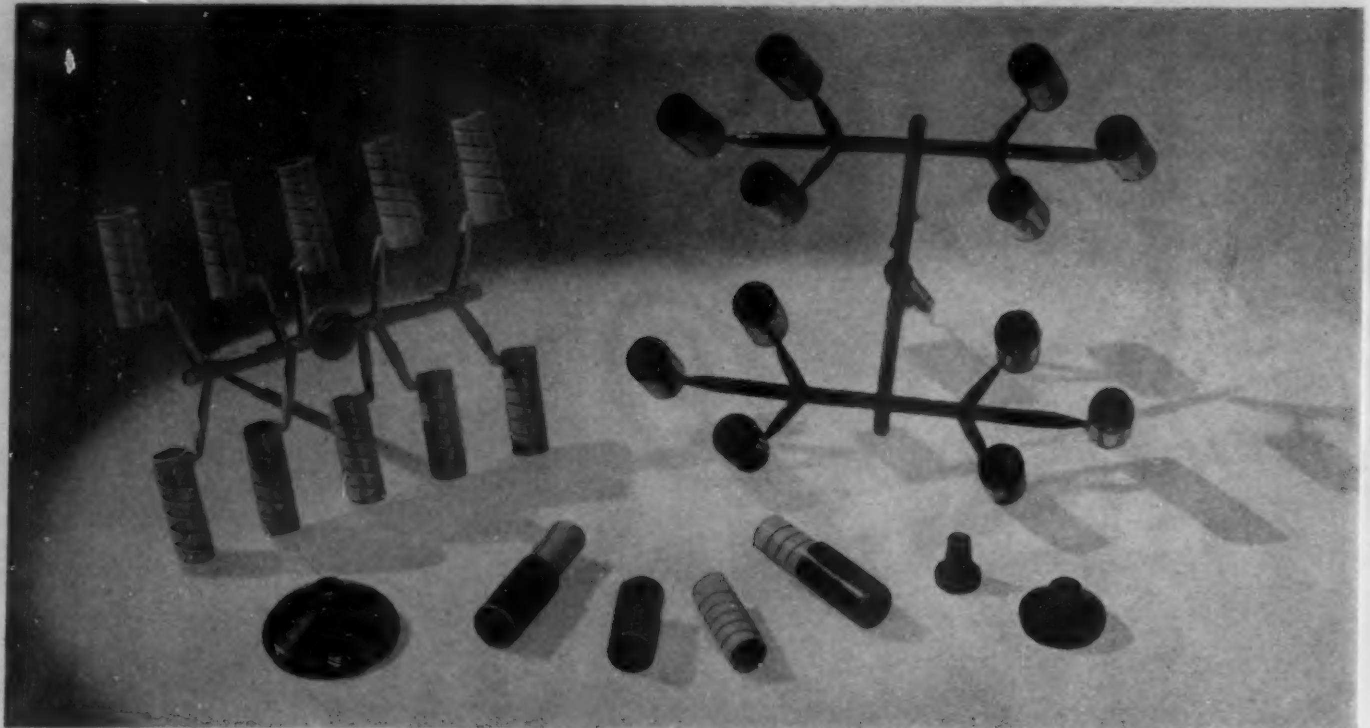
GET THIS GUIDE –



This new "User's Guide" is full of information on where and how to use all types of P-K Self-tapping Screws. File size – fitted with wall hanger. Write for your copy, and invite a P-K Assembly Engineer to call. (Or, send details of fastening jobs and we'll mail recommendations to you.) Parker-Kalon Corp., 208 Varick Street, New York 14.

SELF-TAPPING SCREWS FOR EVERY METAL AND PLASTIC ASSEMBLY

PARKER-KALON
Quality-Controlled
SELF-TAPPING SCREWS



EXTRUSION *and* INJECTION MOLDING

THREADS . . . RODS . . . TUBES . . . SHEETS and other FORMS
SIMPLE, INTRICATE or COMPLEX PARTS or INDIVIDUAL ITEMS

EXTRUSION molding in continuous lengths, flexible or rigid in all types of thermoplastics.

INJECTION molding from expert designing of molds to sustained standards of production and quality.

A competent Engineering and Technical Staff at your Service!

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CELLUPLASTIC CORPORATION

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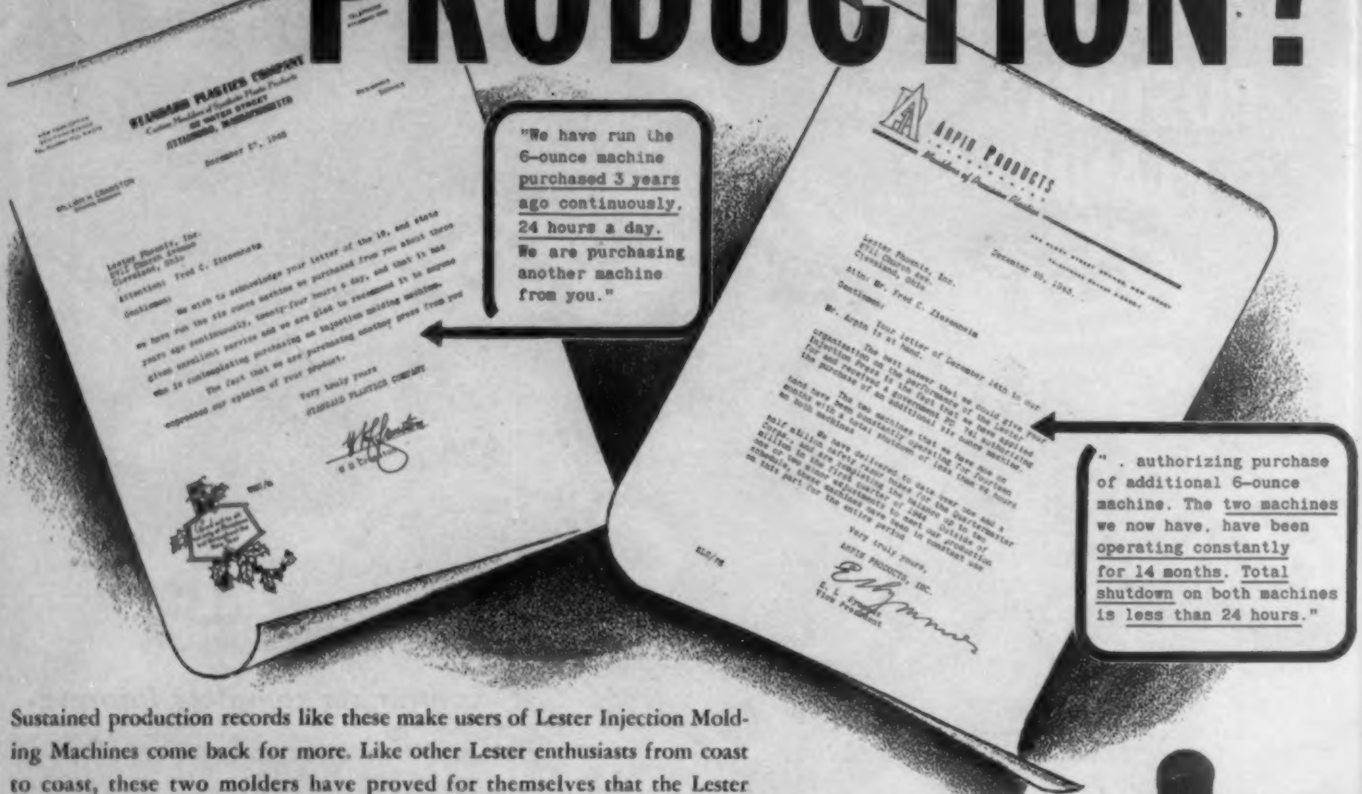
WEST COAST REPRESENTATIVES: CONTAINER SERVICE CO., 1266 North Western Avenue, Los Angeles 27, Cal.

How's this for
PRODUCTION?



Sustained production records like these make users of Lester Injection Molding Machines come back for more. Like other Lester enthusiasts from coast to coast, these two molders have proved for themselves that the Lester delivers the kind of performance it is designed and built for.

Each one of the standard sizes of Lester Injection Molding Machines incorporates all of the features* which are responsible for Lester performance. See for yourself why these modern molding machines are preferred when economical, profitable production of high quality moldings is required. Write or wire for complete data and specifications.

SHAPING THE THINGS OF TOMORROW

*Here's why LESTERS stay on the job...

1. **VERTICAL HEATING CYLINDER** *with hollow injection plunger for high heating efficiency.*
2. **EXTRA, INTERCHANGEABLE HEATING CYLINDERS** *for each model widen operating range.*
3. **POSITIVE DIE LOCKING** *holds flash on moldings to rock-bottom minimum.*
4. **CENTRAL DIE ADJUSTMENT** *assures perfect parallelism of die plates.*
5. **HEAVY ALLOY STEEL BEAM FRAME** *gives rigid support to die locking mechanism.*
6. **SIZE RANGE**—*4, 6, 8, 12, 16 and 22 ounces.*

The 6-ounce Lester is a sturdy, versatile molding machine with the same ability for high production as the other models in the Lester line. From the small 4-ounce to the time-tested 22-ounce size, each is a true Lester.

LESTER

Representatives in
NEW YORK CITY • DETROIT
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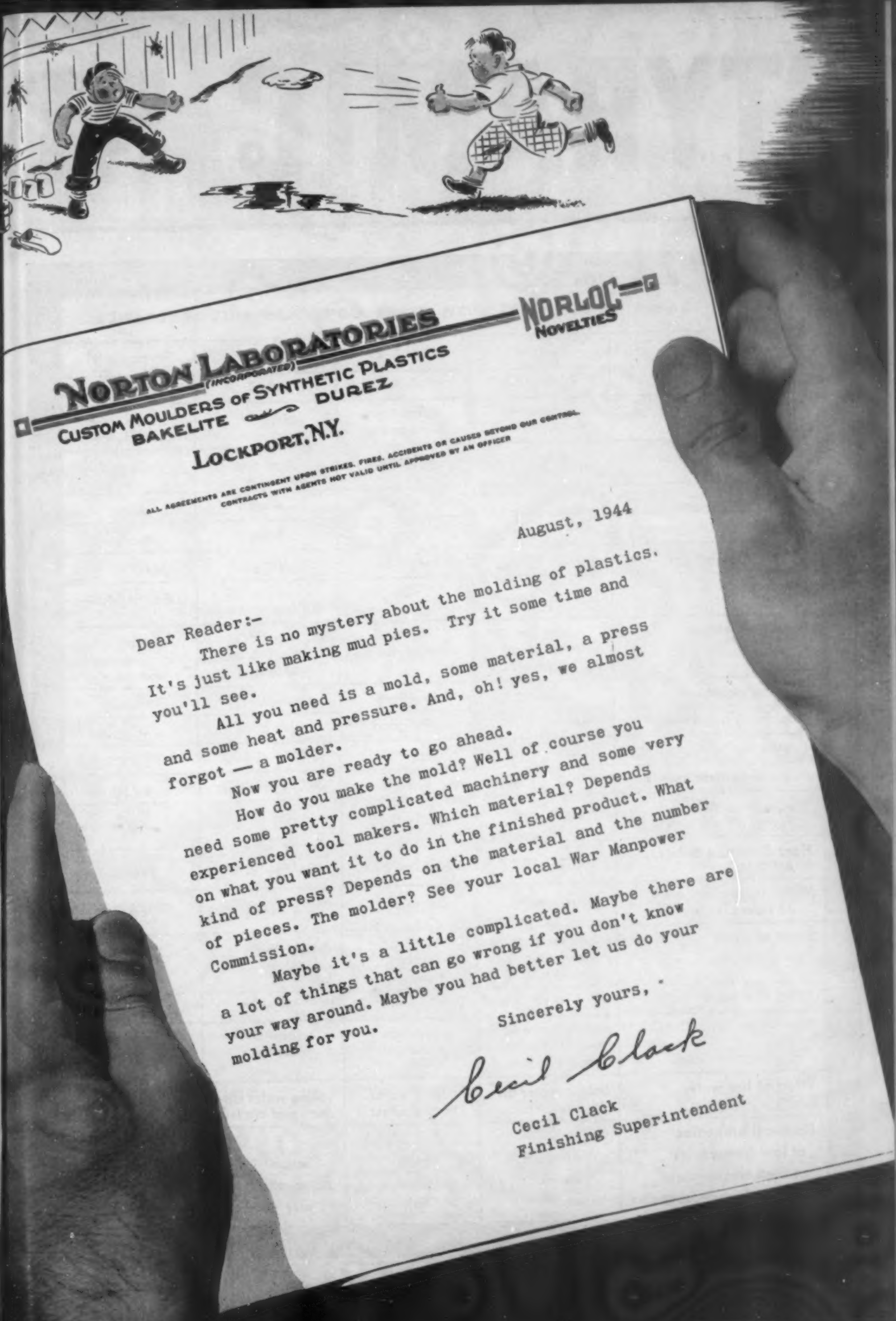
INJECTION MOLDING MACHINES

National Distributors: **LESTER-PHOENIX, INC.** 2711 CHURCH AVENUE CLEVELAND • OHIO



NORTON LABORATORIES (INCORPORATED)
NORLOC NOVELTIES
CUSTOM MOULDERS OF SYNTHETIC PLASTICS
BAKELITE DUREZ
LOCKPORT, N.Y.
ALL AGREEMENTS ARE CONTINGENT UPON STRIKES, FIRES, ACCIDENTS OR CAUSES BEYOND OUR CONTROL. CONTRACTS WITH AGENTS NOT VALID UNTIL APPROVED BY AN OFFICER

August, 1944

Dear Reader:-

There is no mystery about the molding of plastics. It's just like making mud pies. Try it some time and you'll see.

All you need is a mold, some material, a press and some heat and pressure. And, oh! yes, we almost forgot — a molder.

Now you are ready to go ahead.

How do you make the mold? Well of course you need some pretty complicated machinery and some very experienced tool makers. Which material? Depends on what you want it to do in the finished product. What kind of press? Depends on the material and the number of pieces. The molder? See your local War Manpower Commission.

Maybe it's a little complicated. Maybe there are a lot of things that can go wrong if you don't know your way around. Maybe you had better let us do your molding for you.

Sincerely yours,

Cecil Clack

Cecil Clack
Finishing Superintendent

STYRAMIC HT

HOW STYRAMIC HT COMPARES WITH OTHER MONSANTO THERMOPLASTICS				
	Lustron	Cerex X-214	Styramic	Styramic HT
Specific gravity	1.05—1.07	1.08	1.358	1.38
Clarity	transparent (water white)	transparent (light amber)	opaque	transparent (water white)
Color range	unlimited	extensive	grey and natural only	unlimited
Odor	none	none	none	none
Taste	none	none	none	none
Rockwell Hardness	M80—M90	M100	M72	M103
Burning rate	slow	slow	chars slightly but will not burn	self-extinguishing
Molding methods	injection compression extrusion	injection compression	injection compression extrusion	injection compression extrusion
Molding qualities	excellent	excellent	excellent	excellent
Machining qualities	very good	very good	very good	very good
Tensile strength, p.s.i.	6,000—7,000	———	3,000—3,500	5,400
Flexural strength, p.s.i.	8,000—10,000	13,750	6,000—7,000	8,750
Impact strength, Izod, ft. lbs. per in. notch	0.3—0.4	0.35—0.45	0.3	0.27
Heat distortion points, A.S.T.M.	168°F.—176°F.	220°F.—230°F.	184°F.—187°F.	236°F.
Water absorption after 24 hours immersion	0.05%	0.30%	0.046%	0.03%
Effect of acids	none except strong, non-oxidizing acids attack	same as Lustron	same as Lustron	same as Lustron
Effect of alkalis	none	none	none	none
Solubility	soluble in aromatic and chlorinated hydrocarbons	same as Lustron	same as Lustron	same as Lustron
Effect of hot water	boiling water distorts and crazes	boiling water has no effect	boiling water distorts and crazes	boiling water has no effect
Electrical properties				
at low frequencies	excellent	good	excellent	excellent
at high frequencies	excellent	good	excellent	excellent
at ultra-high frequencies	excellent	fair	very good	excellent

NEW THERMOPLASTIC FOR ELECTRONICS

Developed Especially for High Frequency Electrical Insulation . . . Has Best Electrical Properties Ever Attained by a Rigid Plastic . . . *Plus* ASTM Heat Distortion Point of 236°F!

MONSANTO RESEARCH made plastics history last month with announcement of Cerex, the first injection molding material ever developed for use at temperatures above the boiling point of water.

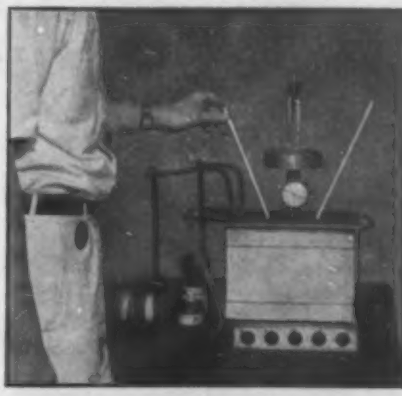
This month comes news of still another noteworthy new Monsanto material — *Styramic HT, a thermoplastic with better high frequency electrical insulation properties than any previous, rigid plastic, plus an ASTM heat distortion point of 236°F!*

Specifically, electrical characteristics of Styramic HT are similar to but even better in ultra high and super high frequency ranges than those of Lustron polystyrene . . . Water absorption is even lower than Lustron's, contributing to exceptionally high dimensional stability . . . And heat resistance is even higher than that of Cerex.

As a result of this unique combination of properties, small quantities of Styramic HT from pilot plant production are already being used for war-vital applications in electronic instruments, and construction of full plant facilities has been authorized. Even when these are completed, however, Styramic HT will be available only for direct military applications that no other material could fill.

After victory, Styramic HT will continue to be important for high frequency insulation parts and for other jobs where its superior properties will contribute to significantly improved performance of the finished product.

As with Cerex, the record-breaking heat resistance of Styramic HT is attained with little or no sacrifice in moldability. Chiefly because it has a sharp melting point, *it can be injection-molded almost as easily as Lustron and is easily extruded by standard techniques.* Although molding temperatures, which range from 475° to 550°F., are somewhat higher than for materials in wide use, they are still within the range of standard injection or extrusion machines.



True measure of any material's heat resistance is its ability to hold its shape *under load* at high temperatures. In the standard ASTM heat distortion test, therefore, a load of 5.5 pounds is applied to the ½ x ½ x 5 inch test bar while the temperature is raised until deflection at the sample's center reaches 0.010 inch.

In this laboratory demonstration the standard ASTM heat distortion test has been further complicated by placing a bar of Styramic HT with a 5.5 pound weight suspended from its center in boiling water. *Even under these conditions, Cerex as well as Styramic HT will maintain its dimensions.*

Other outstanding properties of Styramic HT:

- **an unlimited color range starting with clear transparent**
- **an exceptionally hard surface with a Rockwell Hardness value of M103**
- **non-flammability, being rated as self-extinguishing when subjected to the ASTM tests**
- **excellent chemical resistance, comparable to Lustron**
- **good mechanical strength with tensile values very slightly less than Lustron and flexural values within the same range.**

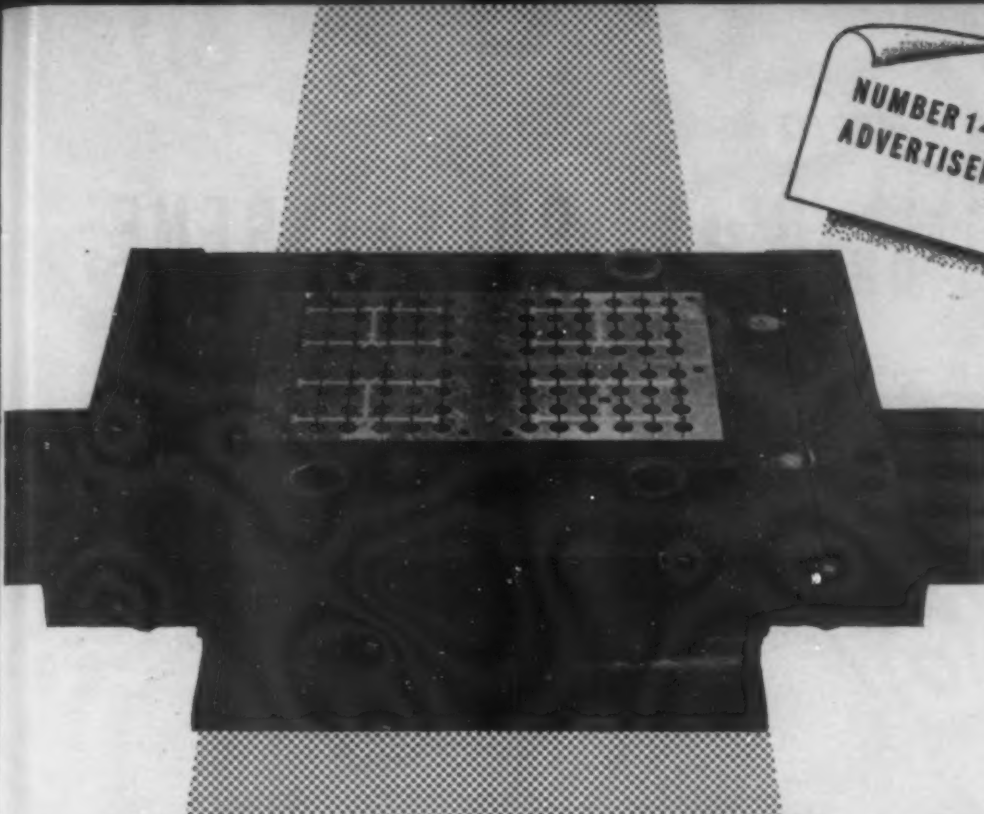
Samples and further information on Styramic HT can be supplied for important military applications requiring a combination of electrical properties, heat resistance and moldability that other materials could not supply. Write or wire: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Massachusetts.

The broad and versatile family of Monsanto Plastics includes: Lustron polystyrenes • Cerex heat resistant thermoplastics • Vynate vinyl acetals • Nitron cellulose nitrates • Fibestos cellulose acetates Resinox phenolics • Resimene melamines. Forms in which they are supplied include: Sheets • Rods • Tubes • Molding Compounds Industrial Resins • Coating Compounds • Vuepak rigid transparent packaging materials.

MONSANTO PLASTICS

SERVING INDUSTRY...WHICH SERVES MANKIND

NUMBER 14 IN A SERIES OF EDUCATIONAL ADVERTISEMENTS ON TRANSFER MOLDING



MORE MOLDINGS PER MOLD

THE TRANSFER MOLDING process saves, among other things, considerable time in the molding process. Depending on the job and the type of mold required, it can be either a semi-automatic or a completely automatic process.

In either case, its unique handling of thermosetting materials in a plastic state enables the molder to turn out perfect pieces in a minimum of time. Cycles as low as 20 seconds have been recorded. The accountant can quickly transform this decreased press-time into increased production per press and per mold cavity.

This fact, combined with the lessened mold wear and consequent lower mold maintenance cost of the TRANSFER MOLDING process, are two of the reasons why more molders are turning to this method.

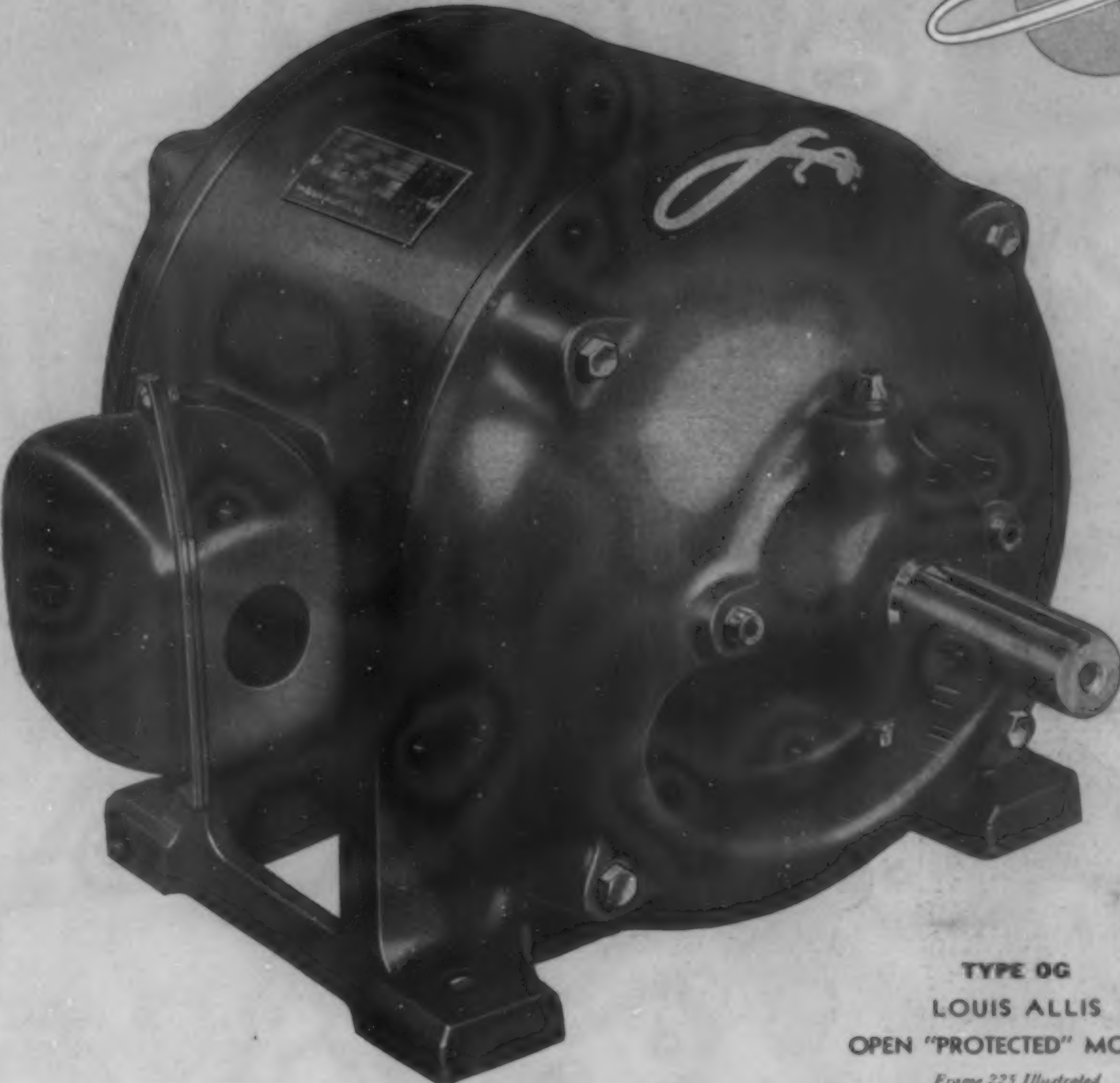
TRANSFER MOLDING *is the best way to*

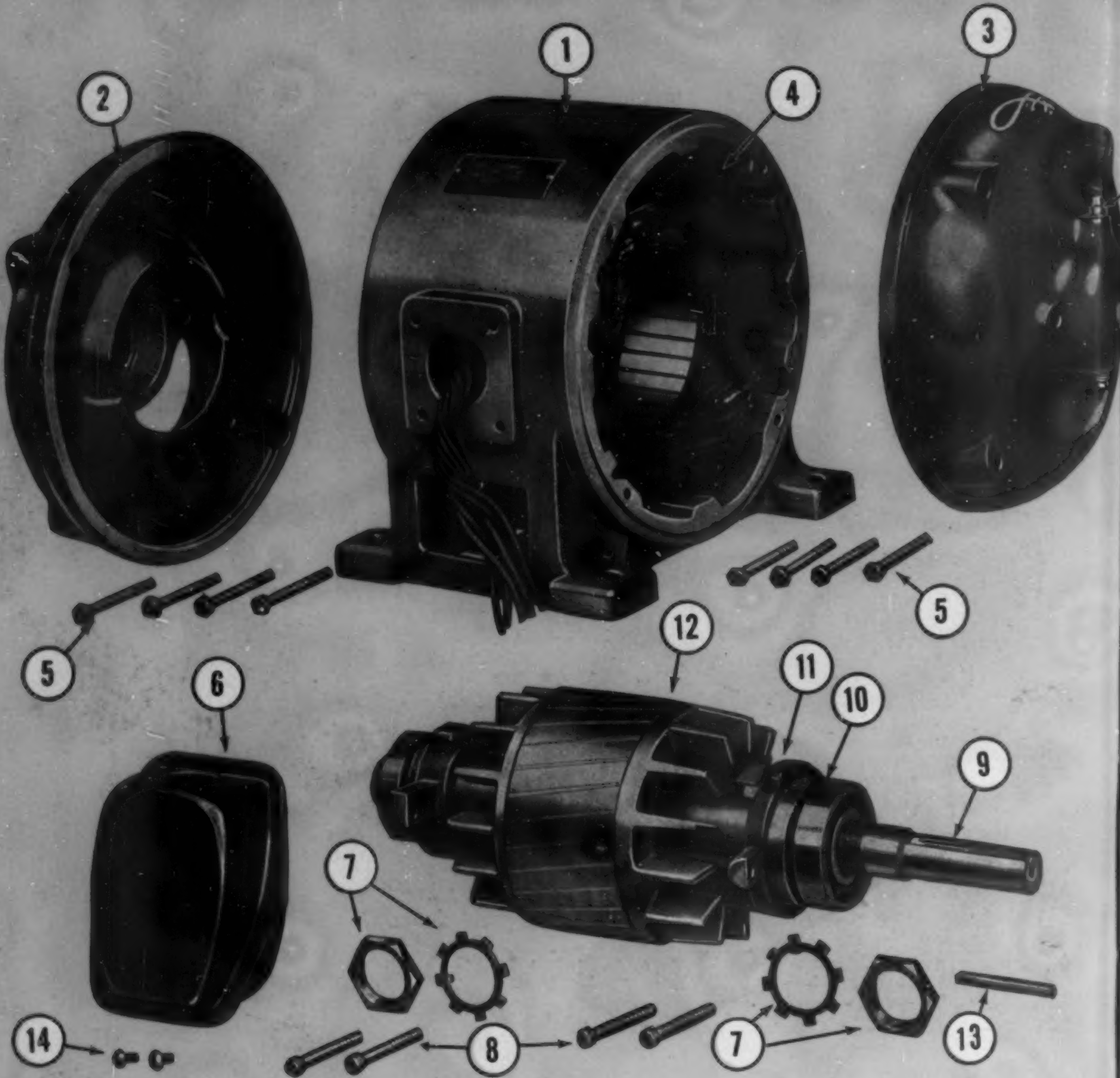
- Handle inserts—metal, glass, ceramic
- Mold high-impact materials
- Mold unsupported cores
- Achieve maximum dimensional accuracy
- Reduce trapped gases
- Lower mold costs
- Lengthen mold life
- Increase molding speed
- Reduce finishing costs
- Improve uniformity of cure regardless of cross-section
- Save material by eliminating flash
- Get practical solution to difficult molding problems

—on thermosetting plastics.

SHAW INSULATOR CO.

IRVINGTON SHAW NEW JERSEY

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NIXON C/N
CELLULOSE NITRATE

Tough ...

Nixon C/N (Cellulose Nitrate) is a really tough plastic. It has "what it takes" to resist impact and wear. It is ideal for hammer heads, tool handles, fountain pens and pencils, piano keys, toys, etc. It is available in sheets, rods and tubes. This versatile, colorful plastic may meet your requirements perfectly. NIXON NITRATION WORKS, Nixon, New Jersey.

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CELLULOSE NITRATE
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The Signal Corps is getting it through mile by tortuous mile

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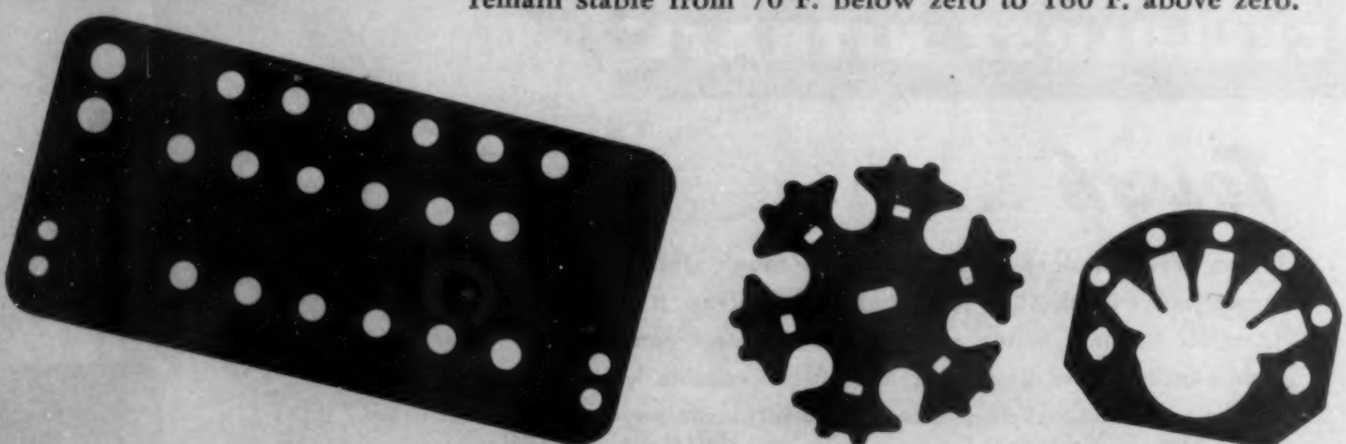
All have a vital role in the giant web of communications which is the unseen hand guiding the destiny of our fighting men in every sphere of action. All of this communications equipment depends on ELECTRICAL INSULATING MATERIALS for its successful operation.

CONTINENTAL-DIAMOND is making thousands of insulating parts for Military Communications Equipment. Parts fabricated from C-D insulating materials engineered to remain stable from 70°F. below zero to 160°F. above zero.



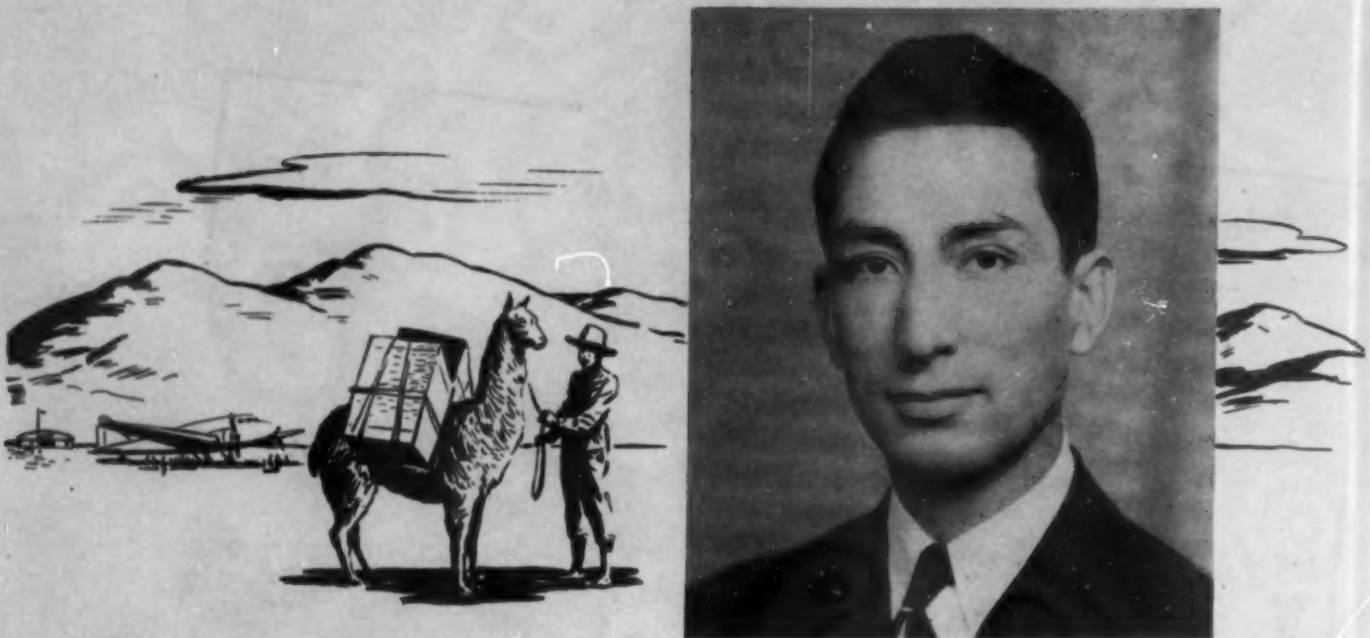
A few of the many C-D insulating parts being made for War Equipment from C-D products DILECTO . . . DILECTENE . . . VULCOID . . . DIAMOND FIBRE . . . MICABOND . . . CELORON. Complete technical data is available in bulletin GF. Write for it today on your business letterhead.

DISTRICT OFFICES: New York - Cleveland - Chicago - Spartanburg, S. C.
West Coast Rep., Marwood, Ltd., San Francisco - Sales Offices in principal cities

CR-44

Continental-Diamond FIBRE COMPANY

Established 1895.. Manufacturers of Laminated Plastics since 1911—NEWARK 28 • DELAWARE



GOOD NEIGHBORS LEARN GOOD PLASTICS

The new generation of our Latin American neighbors is vitally concerned with the industrial future. Typical is Fortunato Portilla Delgado, a successful young businessman of Arequipa, Peru, who realizes the importance of plastics in coming developments and has come to America to study at Plastics Institute. Señor Delgado feels that a knowledge of plastics is mandatory to an intelligent approach to future manufacturing procedure in his country.

It is gratifying to us that students have come from many parts of the world to study at Plastics Institute. It is an indication that the training we give is valuable not only to the student, but to the industry he serves. We shall continue to expand our comprehensive and practical training, enabling our graduates to make a real contribution to the development of the plastics industry. Inquiries regarding our resident and home study courses are invited.

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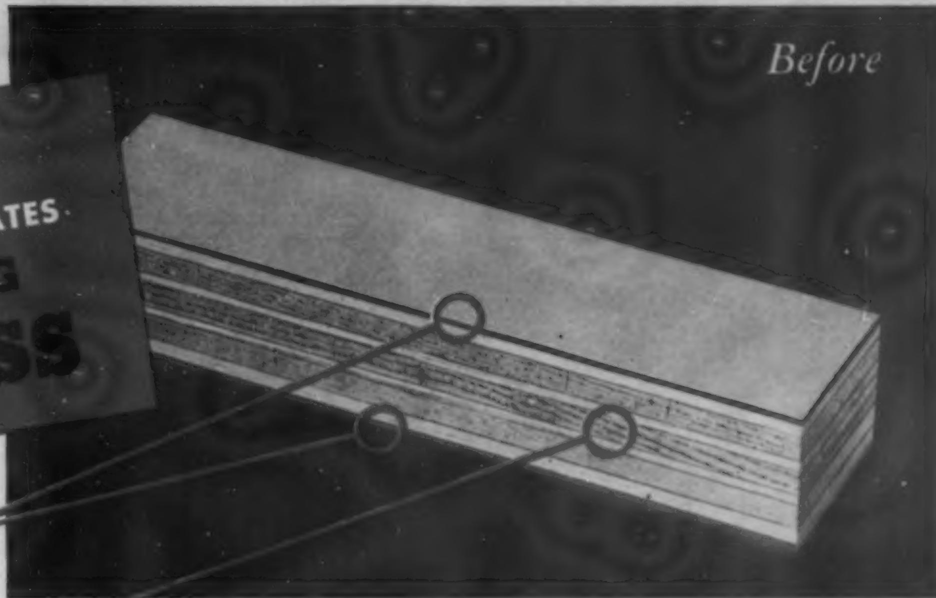
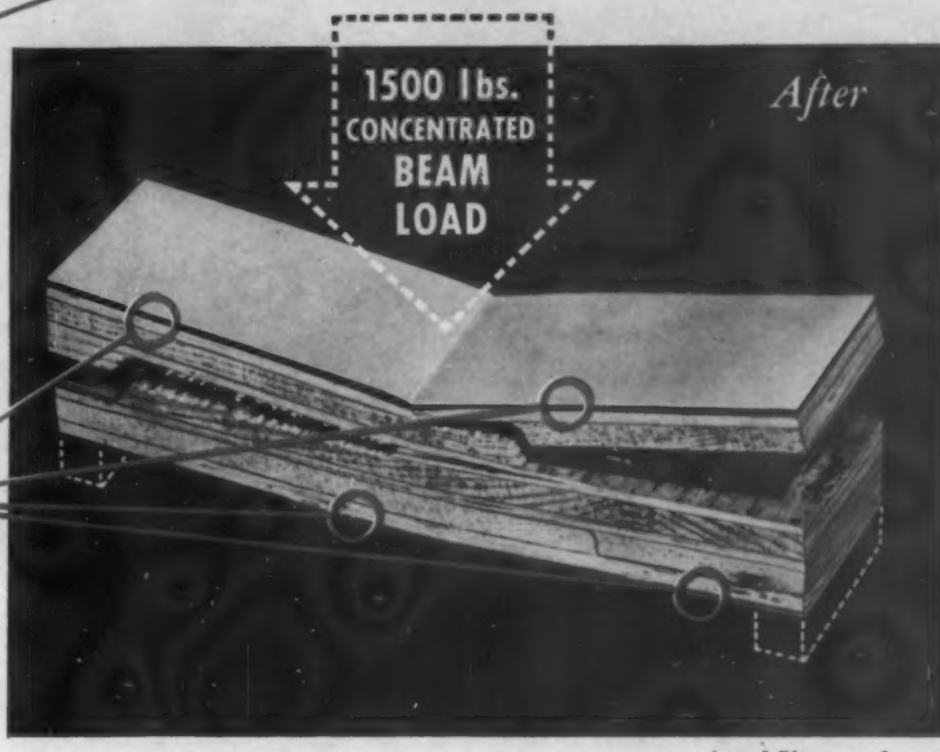
THAT DEMONSTRATES
BONDING
SUCCESS



ALUMINUM
Cordo-Bonded
to
PLYWOOD
(Resin-Bonded Fir Plywood)



Actual Photograph

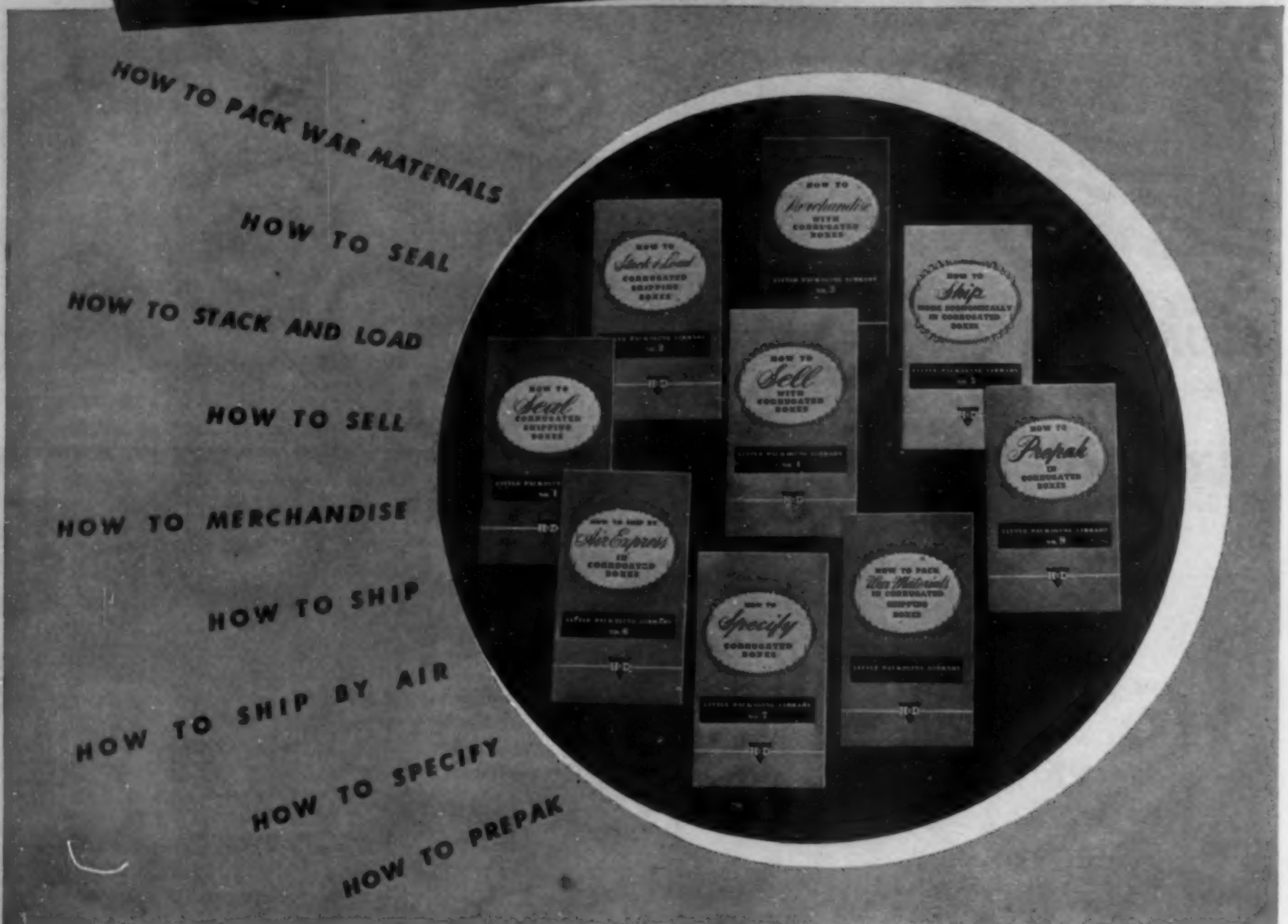
Cordo-Bond
INTACT

CORDO-BOND Adhesives may be able to solve some of your present or post-war problems in bonding *metal, plastics, wood, glass, paper, cloth* or *leather.* Please write, giving details for specific analysis or request Catalogue outlining CORDO-BOND Adhesives, uses, characteristics, bonding processes.

CORDO CHEMICAL CORPORATION
34 Smith St., Norwalk, Conn.
INDUSTRIAL COATINGS • FINISHES
INDUSTRIAL ADHESIVES

CORDO-BOND

9 WAYS TO BETTER POST-WAR PACKAGING



H & D Little Packaging Library—FREE on Request

Packaging war goods — that's the all-important task of H & D today, BUT H & D's war-time activities are bringing a wealth of valuable experiences, and an abundance of new packaging skills and techniques that will have a great and good effect on the progress of post-Victory packaging.

With packaging trends constantly changing and packaging materials under continuous development, H & D published its Little Packaging Library to make your entire packaging procedure more efficient. The "Library" presents the packaging experience of hundreds of manufacturers and contains many real contributions to improved packaging and shipping methods to savings in materials, manpower, machinery and transportation facilities.

Whatever your packaging assignments are today — whatever they will be tomorrow, these booklets will prove of value to you and your organization. The booklets are FREE without obligation — write for as many sets as you need. Address Hinde & Dauch, 4475 Decatur Street, Sandusky, Ohio.

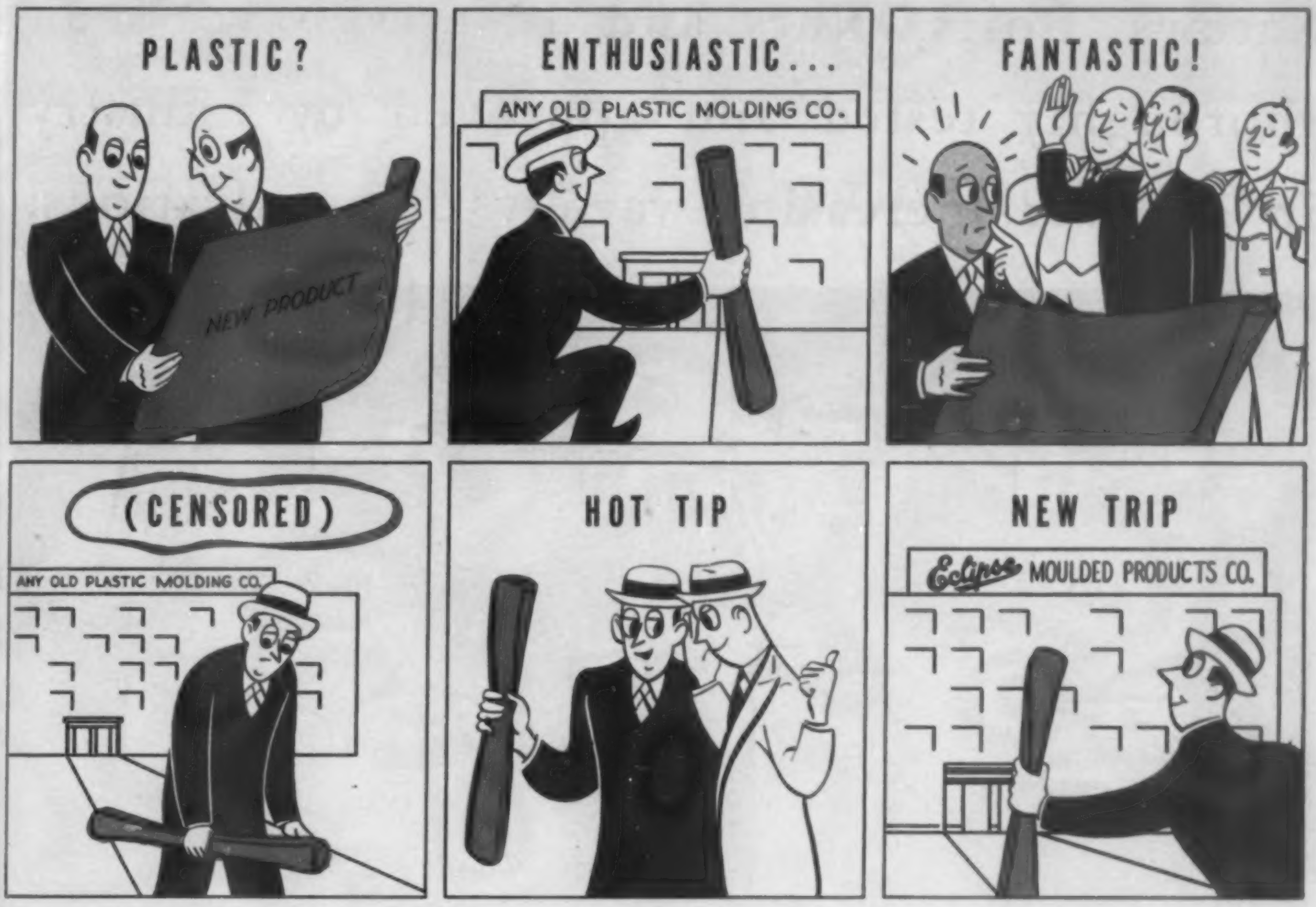
• • •

FACTORIES: in Baltimore • Boston • Buffalo • Chicago Cleveland • Detroit • Gloucester, N. J. • Hoboken Kansas City • Lenoir, N. C. • Montreal • Richmond St. Louis • Sandusky, Ohio • Toronto

For postwar packaging . . better see H&D HINDE & DAUCH

AUTHORITY ON PACKAGING . . . CORRUGATED SHIPPING BOXES

Tomorrow's Headlines in Plastics Come From Eclipse Today!



IF YOU ARE THINKING OF PLASTIC PARTS LARGER THAN ANY PRESENTLY MANUFACTURED...

Consult Eclipse

In the past, many product parts were considered fantastic in plastic, solely because of their large size. This is no longer true. We, at Eclipse, did some dreaming and planning and installed new moulding equipment, capable of producing plastic parts larger than any presently manufactured.

Here, then, may be one answer to the plans of your Design Engineers, and to the leadership dreams of your Sales Manager. At any rate, it costs you nothing to find out. Our new equipment, new facilities, and experienced "know-how" are available for your planning, ready to work with you.

NOTE: A complete fabricating department is operating, producing completed assemblies. This too, may be an answer to some of your production problems.

FACILITIES: *Compression, Injection, Extrusion, Fabrication, Combination Assembly, Design Assistance.*

Eclipse Moulded Products Company

5150—North 32nd Street, Milwaukee 9, Wisconsin

CHICAGO • DETROIT • NEW YORK • CLEVELAND • KANSAS CITY

COMPRESSION • INJECTION • EXTRUSION MOULDING IN ALL PLASTIC MATERIALS

MODERN PLASTICS

AUGUST 1944 VOLUME 21 NUMBER 12

Extrusion blowing of thermoplastics

by HENRY GRIFFITHS*

OVER a period of years, one large New England company has directed much of its development effort toward the successful handling of polystyrene. This development work, chiefly in the field of extrusion, has culminated in the production of highly flexible polystyrene sheet and fiber as well as various forms of continuously extruded rod and tube. The production of very heavy sections of polystyrene, with diameters of 3 to 4 in. and more, held to within microscopically close tolerances, is another of the company's developments of which very little is known outside the immediate circle of their strategic war customers. A further refinement of the heavy section production is a section whose diameter is not constant. Numerous solid shapes with varying diameters have been successfully produced although much research and development work is still being devoted to the ultimate improvement of these special sections.

Many of the above-mentioned products have been developed through the medium, in one form or another, of continuous extrusion. This same company has also developed automatic processes and apparatus for the production of blown plastic articles such as bottles and other types of containers in which the extrusion principle is utilized.

While the principles of the old art of glass blowing are somewhat similar to those of the blowing of plastics, the vast difference between the two materials makes the techniques and "know-how" of the former process inapplicable to the latter. Consequently new processes and equipment were required. Some seven years of concentrated development work were necessary before the manufacturer was satisfied that the basic principles of the blowing and extrusion of plastics had been fundamentally developed.

Celluloid, for example, has been blown for years by clamping two sheets of material between two split halves of the mold, softening it by heat and forcing it out against the mold with air pressure. However, this is not an automatic process and requires much hand labor and time. Several plastics companies have done a great deal of development

* Plax Corporation.

These bottles, Christmas tree balls and toilet float are representative of extruded and blown thermoplastic articles

work which involves injection molding a slug of material around a hollow core, then transferring core and slug to a so-called blowing mold in which they are tightly clamped. Air pressure of approximately 80 p.s.i. then stretches, forces and literally blows the softened plastic material out against the contours of the blowing mold. When the plastic canteen for the U. S. Army was in its experimental stage, its production was attempted along these lines. Due to many factors, the blown version of this item was never satisfactory, but there is no doubt that it could have been successfully produced if many discouraging circumstances had not intervened

On the other hand, extruded and blown articles which the New England company has had in production for some years have worked out well. After the process was developed, various bottles were successfully produced, but difficulties were encountered in marketing them because the properties and cost of the plastics did not adequately meet the requirements for container uses. However, a ready market was found for Christmas tree balls which, because of the availability of cellulose acetate at that time, could be produced in very large quantities. Millions of the balls were sold, but such items had to be eliminated from production because of the strict allocation of thermoplastic materials. Toilet floats have also been produced in large quantities for use in place of copper floats in toilet tanks—replacing a more critical material during the period when Army camps were being built and defense housing was at its height.

At the same time much work was done with the Armed Services in the development of plastic containers to meet medicinal and related needs. Naturally, sterilization of the containers presented a problem, since none of the thermoplastics could be sterilized by live steam. The application of ultraviolet light offered a means by which the bottles could be sterilized quickly and commercially. Thus bottles became available to pharmaceutical and cosmetic fields.

The company describes its machine for blowing hollow articles from plastic materials as follows: "It blows hollow articles from plastic materials by first forming a shape and then blowing this hollow shape or bubble in a mold. Molding powder is fed into a heating and extruding unit in which it is compacted and softened. The heat-softened plastic is given a tubular shape and extruded through the extrusion head or nozzle. The moment the extruded hollow shape or bubble is of the right size and shape, a mold is closed around it and fluid pressure admitted to the hollow shape to cause it to expand in the mold. A knife operates to sever the extruded and blown shape from the extrusion nozzle and the mold moves away from the nozzle. Another mold immediately moves into position in registry with the nozzle, ready to receive the next hollow shape or bubble which is extruded and formed. The molds travel to a delivery station where the blown articles are discharged.

The type of machine shown in Figs. 2 to 4 provides an interesting arrangement for severing the hollow shapes from the extruding head or nozzle. For this purpose, the heating and extruding unit is mounted on a pivot so that the discharge or nozzle end of the unit may be moved up and down. This up-and-down movement is utilized to project and retract a knife blade which performs the severing operation. The machine is adapted to a wide variety of sizes and shapes of molds for the production of various types of articles. It is capable of producing these articles from a large number of molding compounds. The method of operation requires special treatment of the molding compounds to prevent bubbles forming in the material as it is extruded. In some cases, special cooling of the articles is necessary to insure that they will retain the shape of the molds.

Figure 2 is a side view of the blowing machine, showing its general construction. The rotating table mounting the four blow molds is at left center, while a special set-up for cooling

PHOTOS COURTESY PLAX CORP

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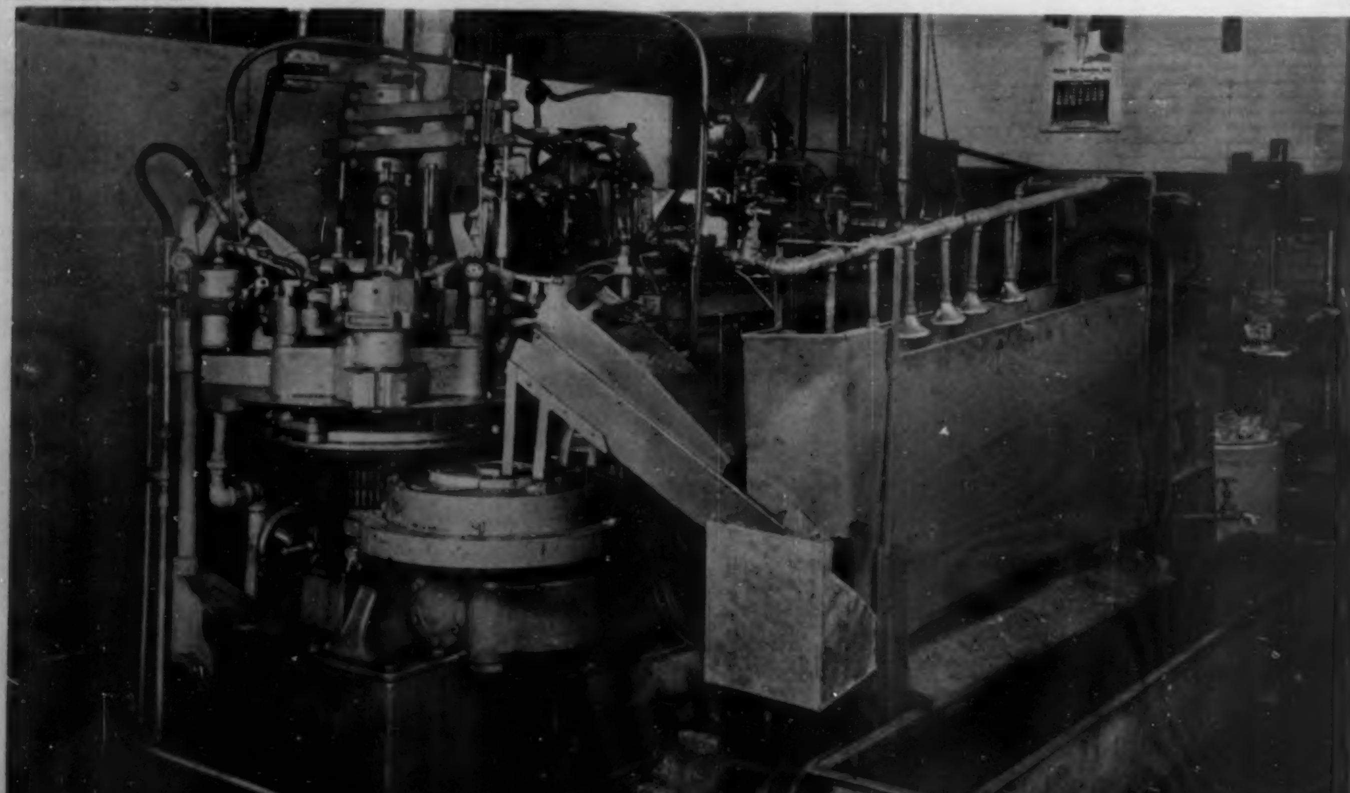

the parts stands at the right. In this cooling unit, spray nozzles mounted directly above a moving belt serve to cool the articles as they are carried away from the delivery end of the machine. The heating and extruding section of the unit is in the left background, parallel to cooling chamber.

Figure 3 is a close-up of the extrusion head and one split blow mold. This photograph shows the formation of a bubble for the production of a large bottle. The bubble, which has been extruded and blown to its present size and shape in the atmosphere, is about to be tightly enclosed in the mold. The blowing will then proceed until the bubble has taken the exact outside contour of the mold. Fitting smoothly at each point, the bubble is formed into a bottle, including the formation of the neck and outside threads.

After the cut-off operation has been completed, this mold with the blown bottle enclosed within it, indexes to the second station. At this point a water connection is made automatically, and cooling water is forced through various channels in the mold to hasten the setting or hardening of the material. The details of this cooling vary widely according to the size and shape of the blown article. As a matter of fact, in some cases it is understood that no forced cooling is necessary. While indexing to the next station, the hinged mold opens so that, when it finally reaches the third stage in the operation, the bottle is held merely by the lower plug which formed its bottom surface.

Figure 4 shows the mold in the open position with the bottle suspended just below a vertical knock-out pin. This pin breaks the bottle loose from the lower plug and starts it down the delivery chute shown in Fig. 2. Then the mold, still in the open position, proceeds back to Station 1, ready to receive another bubble.

A major advantage of the plastic containers produced by this blowing process is their great saving in weight. By a rough rule of thumb, a plastic bottle is said to weigh approximately one-third as much as a bottle made of glass. In addition, because of the thinner wall section possible with plastics, the plastic bottle will occupy less space than a similar glass bottle. Good strength characteristics are another feature, with the cellulosic plastic containers being somewhat better in this respect than those blown from polystyrene.

Because of their light weight, plastic containers have at this particular time found use in the shipment by air of various drugs and vitamins to all parts of the world. Wherever long-distance air shipments are concerned, it has been estimated that the cost of the lighter plastic container plus the cost of air transportation is less than the lower cost of the glass container plus the higher cost of its transportation by air. As a result, a far greater number of the light plastic containers may be carried by air transport than would be possible with the higher and somewhat bulkier glass container. Naturally this is a strategic factor which is of vital importance today.

As is well known, there is no plastic which is completely satisfactory for every purpose. For instance, in one application the Navy found it advisable to use a styrene-type container as a replacement for glass. This is because of the fact that, while the styrene container can be shattered, the effects of the shattering would be negligible should the fragments come in contact with officers and men. If moisture protection had not been an important factor in this particular application, the Navy would have used a cellulose acetate container because of its better strength characteristics.

When polystyrene is used as a container material, it suffers in comparison with cellulose acetate (*Please turn to page 166*)

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2—Side view of the blowing machine. 3—Close-up of extrusion head and one split blow mold shows the formation of a bubble for a large bottle. 4—The finished plastic bottle is suspended just below a vertical knock-out pin

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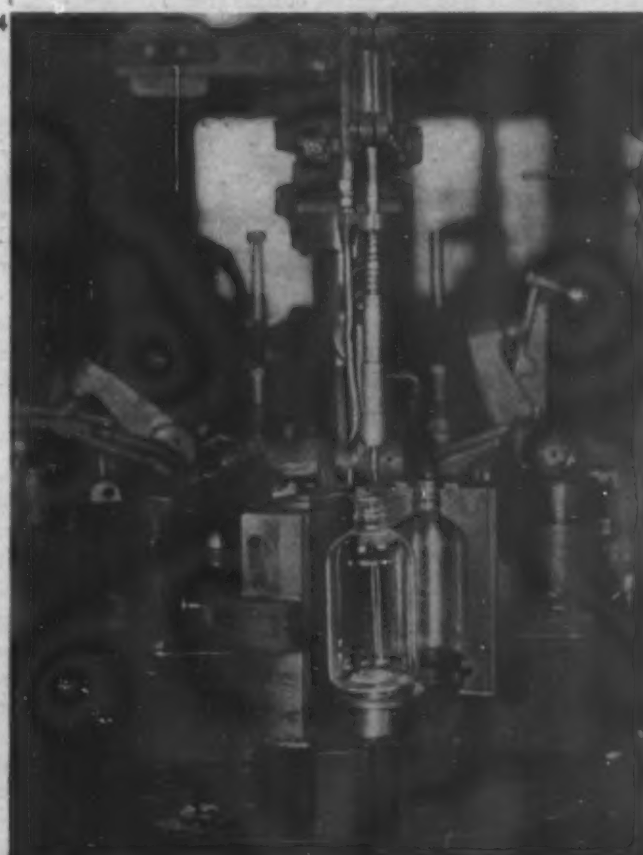

ALL PHOTOS COURTESY PARAMOUNT RUBBER CO.

Safety

by LE GRAND DALY*

OF THE 15 million men and women in the Army, Navy and Marine Corps, many are wearing helmets for the first time. Of course, not all of the helmets worn in military service are made of plastic. But the idea of wearing helmets as protection for the head is certainly one with which many persons will be familiar when they return to civilian life. To make these postwar helmets as comfortable as possible without sacrificing any of the safety qualities, the Paramount Rubber Co., while still engaged in military and high-priority manufacture of plastic sun and safety helmets, has undertaken production of several new designs (Fig. 1).

Safety, comfort and fit are the three major considerations in the design of these helmets. Safety, the feature that has guided the development of the integral parts which go to make up the completed helmet, can be controlled since it is possible to rate the helmet exactly for the stresses it is expected to encounter. Comfort and fit, however, are not so easy to reduce to formulas.

To improve the comfort of the new plastic helmets, special attention has been given to the biological factors that enter into design. Since the greatest cranial variation occurs behind the ears, it is in this space that difficulty in fitting is experienced. To meet this condition, the back part of the helmet has been made larger (Fig. 3). From the ears forward, heads tend to follow a fairly regular pattern.

In this connection, the theory behind the design of safety helmets is interesting. To provide adequate safety margins, there must be enough space between the suspension and the outer shell of the helmet so that a time interval exists between the moment a blow strikes the outer shell and the time it reaches the cranium. This lag provides time for the head to start moving in the direction of the blow—thus cushioning the shock. However, the helmet must be strong enough to absorb the major part of the blow and the resulting damage.

From the point of view of comfort, it is important that the temperature inside a helmet be as cool as possible. Tests carried on by company technicians revealed that substantial reduction in the inside temperatures of the helmets is obtained by metal plating the outside surface. Additional experiments are now being conducted using powdered metal and some form of resin adhesive.

At present the company is manufacturing in commercial quantities, four types of plastic safety helmets:

1. Model C–80—80 ft.-lb. impact, weight 12 oz.
2. Model D–40 (miner's cap)—40 ft.-lb. impact, weight 8 oz.
3. Model M (sun helmet)—20 ft.-lb. impact, weight 8 oz.
4. Model F–100 (firemen's helmet)—100 ft.-lb. impact, weight 20 oz.

The standard 12-oz. sun helmet, which has an impact strength of 80 ft.-lb., is a laminate of impregnated 8-oz. enamelling duck. The resin is of the low-temperature formaldehyde type with an impregnation of 52 percent. The 10 separate pieces of impregnated material which go to make up the crown of the hat are cut in deeply serrated patterns (Fig. 2) which give the effect of long supporting members, reaching from brim to crown. The crown is given further

***1**—The laminated plastic helmets are now produced in 4 models. Reading from left to right, these are the firemen's helmet, the miner's head guard, the combat helmet liner and the sun or safety helmet. **2**—Ten different patterns of impregnated material are used in each helmet*

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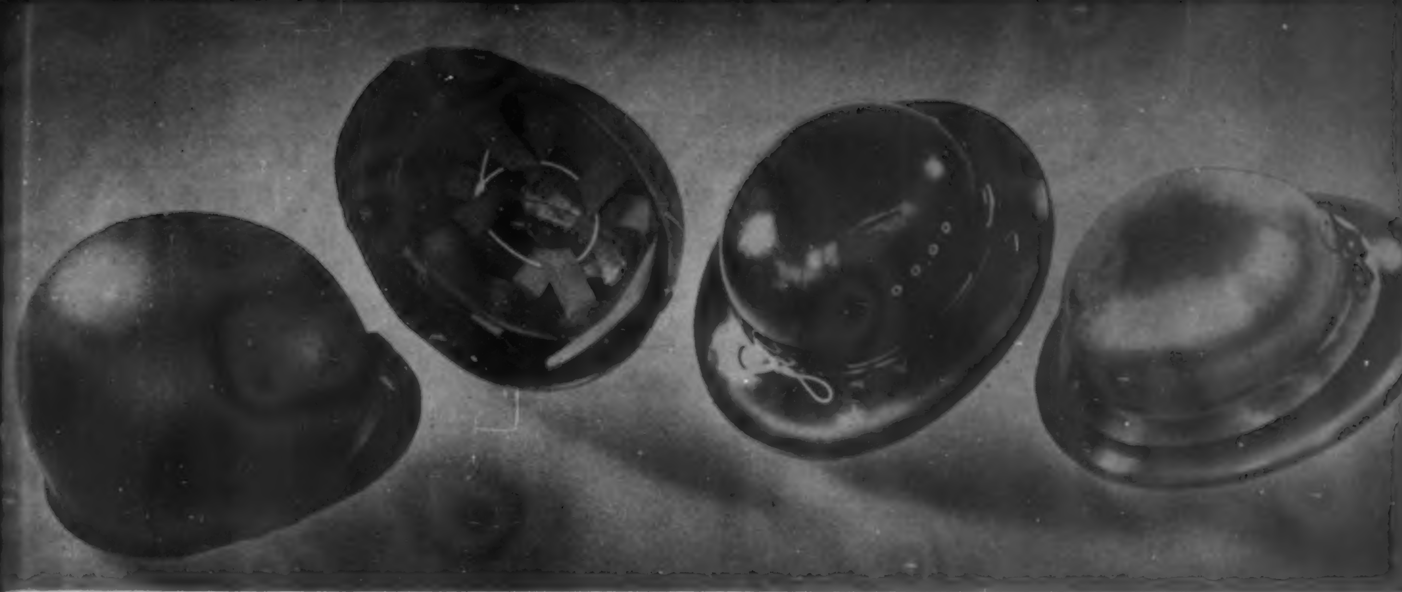
* President and general manager, Paramount Rubber Co.



Helmets

strengthening by the addition of specially designed laminated sections which serve to anchor the supporting members of the main body of the helmet.

For the forming operation the die-cut pieces are assembled in an old helmet shell. When the various thicknesses of impregnated cloth have been loosely put in place, the assembled laminates are transferred to the low-pressure presses. As can be seen in Fig. 5, sheets of cellophane are inserted inside the lay-up just prior to molding. These are removed after the helmets have been formed. Placed in gas-heated molds, the helmets are molded by the rubber-bag process under a pressure of 250 lb. at a temperature of 300 degrees.

Fundamental in the manufacturing process, is the necessity of using only sufficient pressure to form the resin with which the laminates are impregnated without crushing the fibers which constitute the material. To depart from this principle is to weaken the resulting product. A molding cycle of 4 min. has been found adequate.

It has been found necessary to "breathe" the laminate during the molding process to permit the escape of excess gases formed by the heat and pressure. This breathing insures even formation in the material and freedom from surface blemishes that might be present if trapped gases were not permitted to escape. The breathing process is facilitated by insertion of two so-called "breather strips"—2 in. ribbons of canvas—placed crosswise over the top of the lay-up after it is inserted in the mold. These strips do not become a part of the molded helmet—being separated from the impregnated laminates by the cellophane sheet. Consequently, they may be used over and over again.

The finishing operations include removal of flash and the punching of rim holes. The untrimmed helmets are placed over a block and the rough edges removed by burring on a specially designed machine which smooths the edges to the specified dimensions. The helmet is then put on a punch machine where rim holes, which will serve as anchors for the headband suspension, are perforated at a single operation. A series of dies, arranged much like spokes on a wheel, make this punch operation possible. Provision has been made for affixing identifying shields on firemen's helmets and safety lamps on the helmets designed for miners.

All 4 types of helmets can be adjusted to fit all shapes and sizes of heads—from $6^1/_2$ to $8^1/_2$—with space left between the headband suspensions and the inside of the head guard that will act as an additional safety factor and permit circulation of air. The headband suspension allows for individual adjustment. This standardization of pattern has made possible a marked reduction in the number of helmets that must be kept in stock, and present production varies between 700 and 1000 helmets a day.

As a result of tests which show that high-surface finish and plating increase the heat-refracting powers of the helmets and make them cooler, certain of the head guards are now being plated. While cost, at the moment, is one of the principal deterrents to the increased use of plating on helmets, general application should bring about a reduction in price. No data is now available on the comparative cost of applying powdered metal, but it is thought that this method may prove to be cheap in commercial volume.

In a test to determine whether (*Please turn to page 160*)

3—This cutaway section of a safety helmet shows the extra air space left in the rear of the helmet to accommodate variations in head size which usually occur behind the ears. The use of an adjustable headband allows a few stock patterns to be fitted to a wide range of sizes

3

Bad news for fish

PHOTO COURTESY CHARLES F. ORVIS CO., INC.

BAMBOO—or Chinese Tokin cane, as the best varieties are called—has long been used in the manufacture of fine fishing rods because of its light weight and long, strong fibers. Even small boys and the rankest of amateurs who, ironically, often catch the most fish, prefer bamboo poles because of their strength and flexibility. But such home-made gear is a far cry from the 2- and 3-piece perfectly balanced split bamboo rods which the elite of the fishing fraternity use in their tall-tale battles.

However, for all its virtues, bamboo is not perfect. When properly seasoned and treated the wood dries out, leaving a myriad of air cells or cavities throughout the cane. Because of this open cellular structure, the strong fibers tend to weaken gradually and to break down eventually under the strain of repeated use. Moisture and bacteria find their way into the open pores and, ultimately, cause the finest of rods to break.

In an effort to overcome this weakness of bamboo rods, conventional manufacturing procedure has been to use varnishes to seal the fishing rods against moisture. But this coating will inevitably nick and chip. Renewing the finish restores the appearance of the rod, but it cannot halt the natural deterioration inside the structure. Nor will conventional cements withstand the elements of time, temperature and moisture changes. As a result, the best of the conventional rods, if not properly cared for, will occasionally come apart. In addition these rods tend to "set" as a result of continued usage—to distort in such a manner that their accuracy is disturbed.

The Charles F. Orvis Co., with a background of 70 years in the manufacture of fishing tackle, began in 1940 to delve into the possibilities of impregnating bamboo with phenolic resins and cementing the rod segments with phenolic resin cements. Such technique, the company reasoned, might render the bamboo impervious to moisture, eliminate the necessity for any protective coating of varnish, further strengthen the fibers and even permit the retention of original accuracy in the finished rod. Experimental work proceeded by the trial-and-error method over a considerable period of time without a great deal of success. Many formulae were tried and tested throughout every stage of manufacture, until a phenolic resin cement and a penetrating resin were found which imparted the desired characteristics to the cane and were adaptable to the precise methods of manufacture. Inasmuch as process patents have been applied for and are pending, it is not possible to divulge the formulae for the cement and impregnating resin or the techniques employed for impregnation, cementing and curing of the rod.

It is doubtful if many fishermen have any conception of the skill required to produce a fine fishing rod, or the precision necessary in each of the many stages of manufacture to obtain the great strength and fine balance characteristic of expensive equipment. After the carefully selected lengths of bamboo have been seasoned, they are split lengthwise into the desired sizes. Mismatching is the next step. Trained workmen sort the bamboo pieces in such a manner that, in lots of six, the nodules—or natural joints of the cane—are as far apart as possible. This painstaking procedure is necessary because the nodules are the weakest points in the bamboo. Each individual piece is then milled to a triangular shape and tapered in accordance with requirements. Six perfectly sorted and mismatched triangular segments are then assembled for the make-up of each rod section. When cemented together, these bamboo pieces form a solid hexagonal structure—the conventional shape of the finished fishing rod.

After the rod sections are sanded, buffed and polished, they are fitted with hand-made (*Please turn to page 166*)

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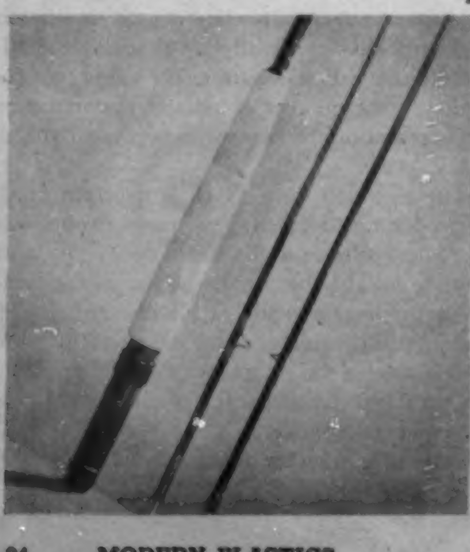

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2—These fishing rods, fabricated of bamboo segments which are impregnated with a phenolic resin and cemented together with a phenolic resin cement, are impervious to moisture, stronger and much more accurate than conventional bamboo poles. 3—Phenolic impregnated bamboo poles are also used in ski poles, golf clubs, in billiard ball cues and in baseball bats

PHOTO, COURTESY BOEING AIRCRAFT CO.

Shatter-resistant plastic glazing

by G. M. KUETTEL*

WAR exigencies have created many demands upon the plastics industry and have provided the incentive for the development of many new plastics and combinations of plastics. One such development is shatter-resistant plastic glazing which is capable of resisting shock-impacts, such as the effects of penetration by machine-gun and cannon fire, or gunfire concussion.

Need for the development

The strategy of modern aerial warfare involves aircraft which can operate at high altitudes, many in excess of 35,000 feet. At high levels the atmospheric pressure is low, oxygen rarer and temperatures low. Table I (shown on page 87) portrays these conditions.

Because of this low atmospheric pressure at high altitudes, it is necessary to supply additional pressure to the fliers who must rise to these heights, since the partial pressure of oxygen in the lungs of the flier may be too low to sustain life, even though he may be breathing pure oxygen. A practical solution to this problem has been the development of the pressurized airplane cabins. The cabins are so constructed that they can be pressurized to the point at which the internal atmospheric pressure, at 40,000 ft. for example, is equivalent to the atmospheric pressure existing at 12,000 ft., the highest altitude at which humans can live efficiently without accessory oxygen. The cabin pressure satisfying this condition is about 7.5 p.s.i. Figure 1 shows a Boeing B-29 Fortress, one of the first superbombers to possess pressurized cabins.

Another valuable attribute of the pressurized cabin is the added comfort and freedom it provides bomber crew members. Under conditions of non-pressurized high-altitude flight, it is necessary for the aviator to wear heavy clothing—often heated suits—and to use oxygen masks. Because of the long range of the huge bombers, crew members would be encumbered for the several hours necessary to reach the target and return. The development of the pressurized cabin eliminates the continuous use of the cumbersome heated flying suits and oxygen masks. However, this equipment may be donned prior to the bomb run in order to avoid interruption by sudden deflation should an enemy shell pierce the fuselage. The advantages thus gained are comfort for the crew members and maintenance of physical and mental alertness which permits of more accurate bombing and better gunnery.

Problems involved

One of the most serious problems accompanying the development and use of pressurized cabins has been the risk of failure of the glazing, that is, the canopies and sighting domes which constitute the transparent portions of the cabin. Under conditions of pressurized flight these observation sections are also under high stress. Instances of sudden rupture of glazing have been reported, and the outward rush of air has actually blown a crew member overboard. Fortunately he wore a parachute and had oxygen equipment attached. In this particular instance, a redesign of the attachment of the glazing to the cabin was necessary. The changes made in the method of attachment avoided eccentricities in loading and subsequent failure of the glazing due to flexural fatigue and notch-sensitivity.

Assuming the correct use of mounting attachments, one of the remaining problems attendant upon the use of plastic glazing in pressurized aircraft is to make the glazing resistant to shattering when penetrated by enemy gunfire. A desirable goal would be to have a transparent easily shaped lightweight glazing material capable of resisting penetration by gunfire. In the absence of such a material, however, it is desirable to have glazing which, when penetrated by enemy gunfire, will be self-sealing; that is, the hole left by the pas-

*Assistant manager, Technical Service, Plastics Dept., E. I. du Pont de Nemours and Co., Inc.

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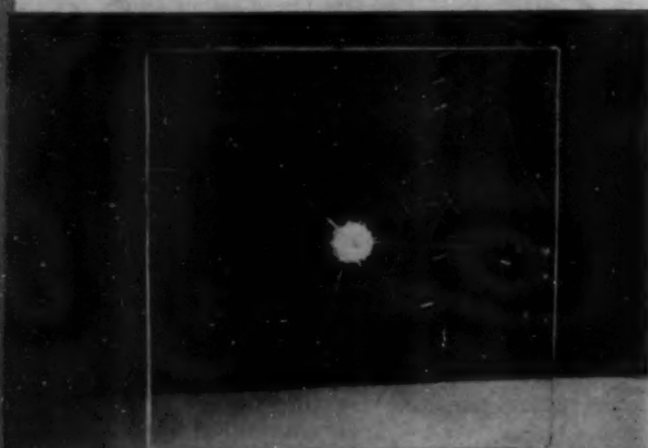

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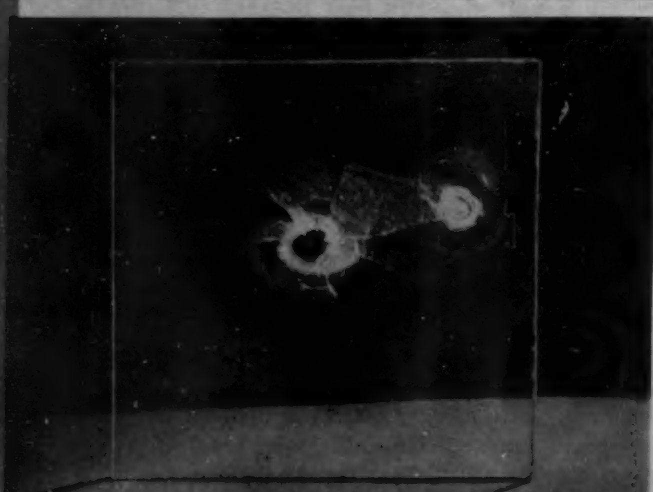

sage of the bullet will immediately close up and prevent loss of pressure. If, because of the properties of the glazing, self-sealing is not accomplished under the severest conditions of low temperature, we must be satisfied with a glazing material which permits the formation of a hole of minimum diameter and has a limited fracture area. Under these conditions the canopy dome or window is not completely disintegrated, and the hole may be quickly closed with a transparent temporary patch. This allows the air pressure to be maintained. Permanent repairs or replacements can be made when the ship returns to its base.

Development of materials

Methyl methacrylate plastics have become standard glazing materials in aircraft because of their low specific gravity, excellent light transmission, ease of shaping, dimensional stability and good weather resistance. However, the stress loading of glazed structures under conditions of pressurized high-altitude flight or excessive flight loading during combat creates conditions under which these plastic enclosures are likely to shatter if penetrated by bullet or flak.

To meet these requirements, the ideal plastic must possess transparency, the ability to be shaped and the simultaneously contradictory properties of rigidity with maximum flexibility under shock impact to prevent shattering. Since no one plastic possesses all of these properties, it seemed logical to utilize the desirable properties of rigidity, hardness and weather resistance of the methyl methacrylate plastics and the toughness and shock resistance of another plastic. The combination of the two materials might result in a lamination possessing the desirable qualities of each of its individual components.

2—This laminated safety plastic, like safety glass for automobiles, resists shattering with a film of vinyl butyral resin. 3—After components of the laminate are laid up, heat and pressure are applied to produce transparency in the interlayer sheets of vinyl butyral resin. 4—Good adhesion, which produces a strong bond between the laminate components, results in a minimum spalling and fracturing. 5—Poor adhesion with an attendant weak bond between the laminate components, results in separation of acrylic and vinyl butyral layers, and a wider area of damage. 6—Under severe crushing, the vinyl butyral resin interlayer shows impact resistance, and the acrylic resin exhibits excellent adhesion.

ALL PHOTOS, COURTESY E. I. DU PONT DE NEMOURS & CO., INC.

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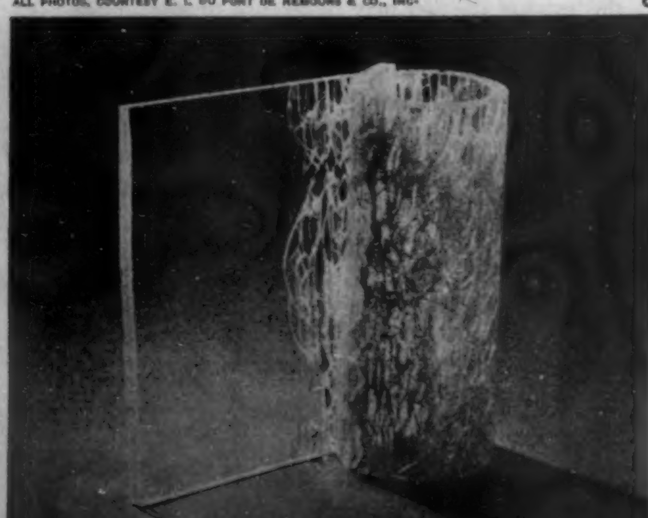

TABLE I.—ALTITUDE-TEMPERATURE-PRESSURE DATA		
Altitude	*Pressure*	*Temperature*
feet	*p.s.i.*	*°F.*
Sea level	14.70	Normal
5,000	12.23	41.2
10,000	10.11	23.3
15,000	8.29	5.5
20,000	6.75	−12.3
25,000	5.45	−30.1
30,000	4.36	−48.0
35,000	3.46	−65.8
40,000	2.72	−67.0

The plastic chosen for its tough, elastic, impact-resistant qualities was made of polyvinyl butyral resin. The laminate is a sandwich made up of two layers of methyl methacrylate resin with a layer of polyvinyl butyral resin between them.

To meet this urgent wartime problem, the experience and skill gained in making laminated safety glass was employed. Laminated safety glass is made up of a sheet of plastic—polyvinyl butyral resin—and two plates of glass, the whole united by heat and pressure. When broken by impact, the pieces of glass adhere to the plastic instead of flying in all directions. In essence, then, the lamination of methyl methacrylate with polyvinyl butyral sheeting may be termed a "laminated safety plastic."

Special adhesives to make product practicable

The transition from the manufacture of a glass-plastic lamination to an all-plastic lamination was not at all.

7

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***7**—The cell that compresses the sheets of acrylic and vinyl butyral is enclosed in a rubber bag prior to immersion in the autoclave. **8**—This equipment is employed in the testing of pressurized semi-cylinders. **9**—The rupture of the 1/2 in. thick wall of a pressurized acrylic semi-cylinder occurred during a test in which the pressure differential was 7.5 p.s.i., the temperature −40°F. A .50 caliber bullet was used in the test. **10**—This 3/8 in. thick laminated acrylic and vinyl butyral semi-cylinder shows no rupturing and small bullet penetration holes after being shot under conditions where the pressure differential was 7.5 p.s.i., the temperature −40°F. A .50 caliber bullet was employed in this experiment*

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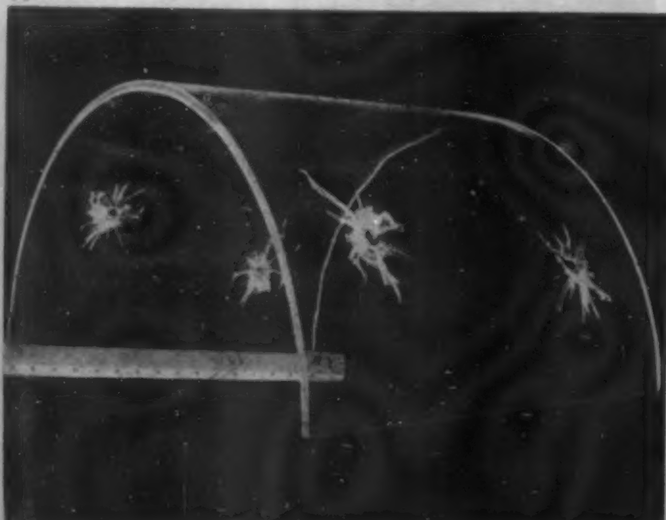

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simple. Though polyvinyl butyral sheeting will adhere to glass without use of additional adhesive, no comparable adhesion could be obtained between this sheeting and rigid methyl methacrylate. It was necessary, therefore, to develop a special adhesive which could be applied either to the methyl methacrylate or to the polyvinyl butyral, and which would produce a strong bond.

Proper adhesion of the components of the laminate is necessary if maximum shock resistance with minimum spalling and fracturing is to be obtained. Poor adhesion in a lamination usually results in separation of the layers when struck by missiles and the accompanying development of translucency in area around point of penetration.

Several hundred adhesives were tried before a satisfactory type was obtained. The testing procedure was quite simple. The lamination, after pressing, was cooled in a refrigerator to approximately 0° F. The sample was then crushed against a hard surface with a hammer. In cases where there was little or no adhesion, the outer layers separated and fell off from the butyral interlayer. However, if the adhesion was good, it was possible to crush the laminate so thoroughly that it could be rolled up like a rug. The interlayer of vinyl butyral resin held broken pieces of acrylic resin in place.

Laminating technique

The method worked out for obtaining laminations with good adhesion and good optical properties, which would not develop bubbles during the shaping operation, is not identical with any commercial method of producing glass laminates. The process involves pressing the plastic laminations between glass plates by means of a high vacuum applied in a rubber bag. It was found essential that all the air be removed from the interface and that the moisture content of the butyral sheeting be low. If the air and moisture are not adequately removed, experience shows that they sometimes reappear as bubbles in the interlayer when the flat sheets are heated prior to shaping. The evacuated and sealed bag is placed in an oil autoclave at 200 p.s.i. pressure and 285–300° F. temperature for time periods that depend upon the thickness of the lamination. The oil is then cooled to 120° F., and the lamination removed.

It is evident that laminations can be manufactured of any manner of lay-up or of any proportionality of thickness of components. Also, they can be of either balanced or unbalanced construction.

Reaction to gunfire

Numerous shooting tests were made on a wide range of laminations under various conditions of temperature and pressure. One of the first pieces of equipment used for conducting such tests is illustrated in Fig. 8. The equipment was so constructed that the plastic semi-cylinder could be pressurized with about 7.5 cu. ft. of air in two drums (A), and could be cooled with a mixture (*Please turn to page 180*)

11—Test dome mounted on 50-gal. steel barrel with thermocouples in position. 12—Disintegration of 1/2-in. wall of acrylic dome. Press. diff., 5 p.s.i.; inside temp., 50° F.; outside temp., −49° F. A .50 caliber bullet used in tests. 13—Bullet hole in pressurized 0.625 in. thick laminated dome is small enough to retard pressure loss. Test conditions same as Fig. 12 except for outside temp. of −40° F. 14—Dome in Fig. 13 patched, repressurized, reshot

11

13

12

14

[a] "Lucite"—regular aircraft grade sheeting, formula HC-201
[b] Laminated "Lucite"–"Butacite" sheeting, 0.400 in. total thickness comprising 0.125 in. "Lucite," 0.150 in. "Butacite," 0.125 n. "Lucite." "Butacite" contained 27.5 parts dibutyl sebacate plasticizer.

TABLE II.—GENERAL PROPERTIES OF METHYL METHACRYLATE AND THE LAMINATE

Property	Test method	Methyl methacrylate[a] cast sheets −70° F.	Methyl methacrylate[a] cast sheets 77° F.	Methyl methacrylate[a] cast sheets 170° F.	Laminated acrylic-butyral[b] sheeting, 0.400 in. thick −70° F.	Laminated acrylic-butyral[b] sheeting, 0.400 in. thick 77° F.	Laminated acrylic-butyral[b] sheeting, 0.400 in. thick 170° F.
MECHANICAL							
Tensile strength, p.s.i. (rapid loading 0.3 in./min.)	D638–42T	12,500 (−40° F.)	7600	....	11,000	6500	2400
Long-time tension	D674–42T	....	Withstood 4000 p.s.i. for over $5^1/_2$ mo.	....	10,000 p.s.i. for over 100 hr. (no sign of failure)	Stress failure 4000 p.s.i. 6 hr. 2300 p.s.i. 16 hr. 1600 p.s.i. 10 days 1200 p.s.i. 23 days 1000 p.s.i. 30 days	....
Elongation at rupture, percent	D638–42T D412–41	.... 0.08 (−40° F.)	6.0	.... 150 (140° F.)[a]	1.0 1.0	3.0 3.0	>35.0 at 140° F.
Flexural strength, percent (slow loading, 0.05/min.)	D650–41T	24,000	14,000	2000	Perpendicular to laminae: 19,000	Perpendicular to laminae: 2300 ("Butacite" squeezed out)	Perpendicular to laminae: 1600
					Parallel to laminae: 16,000	Parallel to laminae: 6600	Parallel to laminae: 500
Modulus of elasticity							
In flexure, p.s.i.	D650–41T	....	$4–5 \times 10^5$	....	....	2.1×10^5	....
In tension, p.s.i.	D638–42T	....	$3–5 \times 10^5$	....	....	....	....
Impact strength, ft. lb./in. of notch—Charpy	D256–43T	0.50	0.55	0.59	0.4	4.6	....
Hardness							
Rockwell	D229–42	....	M-101	....	M-95	"Butacite" squeezes out, unless edge-restrained	
Durometer A	D676–42T	....	....	....	....		
THERMAL							
Coefficient of linear expansion	D696–42T	$7–9 \times 10^{-5}$			$7–9 \times 10^{-5}$		
Heat distortion	D648, proposed revision	79° C.			70° C.		
Thermal conductivity cal./cm.^{2}/sec./°C./cm. Btu/ft.^{2}/hr./°F./in.	Cenco–Fitch apparatus	6×10^{-4} 1.5–2.1			5×10^{-4} 1.3		
Index of refraction, n_D 25° C.	D542–42	1.496			1.479		
Light transmission	....	90–92 percent			90–92 percent		
Haze	D672–42T	1 percent			2.5 percent		
MISCELLANEOUS							
Specific gravity	....	1.18–1.20			1.13		
Mar resistance	D673–42T	60 percent			60 percent		
Water absorption, percent	D670–40T	0.2			1.2 ("Butacite" edges exposed)		
Outdoor exposure	....	Excellent			Light transmission	Weathered sample 1 yr. in New Jersey 90 percent	Control 91 percent
Accelerated weathering	LP–406A Method 6021	No crazing in 500 hr			No crazing in 500 hr.		
Flammability, in./min.	D568	1			1		

[a] "Lucite"—regular aircraft grade sheeting, formula HC-201
[b] Laminated "Lucite"–"Butacite" sheeting, 0.400 in. total thickness comprising 0.125 in. "Lucite," 0.150 in. "Butacite," 0.125 n. "Lucite." "Butacite" contained 27.5 parts dibutyl sebacate plasticizer.

Aqua dyes for clear plastics

by E. F. LOUGEE*

NO ONE questions the scintillating beauty of clear plastics, nor denies that there are times when rich, transparent colors add to this beauty in a practical way. Stop and Go signals in our traffic lanes would be valueless without red and green to guide and control traffic. The colors add no beauty to signal lights, but they do add meaning. The same is true of port and starboard lights on ships at sea. Even more important are the colored signals employed by our Armed Forces in combat zones to identify the sender when transmitting messages from ship to shore, from ship to ship, and from aircraft to carriers and landing fields. Colored lenses may be used on wing tips to identify friendly craft, and colors may be changed from night to night according to a prescribed code planned in advance.

In contrast to common traffic signals which are usually made of glass, aircraft and signaling lenses are frequently fabricated from clear plastics because of the well-known ability of these materials to withstand shocks without breaking and because of their exceedingly light weight. Although the colors are not inherent in these plastics, they must nevertheless be true and fast.

Acetate sheets are available in color—dyed in the wool as it were by the manufacturer—but acrylics are usually made clear. White standard sheets of colored acetate are sometimes used for signal lenses. The more common practice is to dye the required number of sheets to match an exact sample at the point of fabrication, or to dye the lenses after they are shaped. The reasons for this practice are obvious. The right number of sheets of the exact shade of color required for a particular application are not always available at the time they are needed most. If repairs are to be made in a Pacific jungle, or if the color of the lenses is to be switched for a night flight and one color is missing, there is hardly time to send to Newark, Springfield, Kingsport or Arlington to get the right shade of acetate sheet. Spot dyeing is the logical way of meeting such circumstances—and that is how it is done.

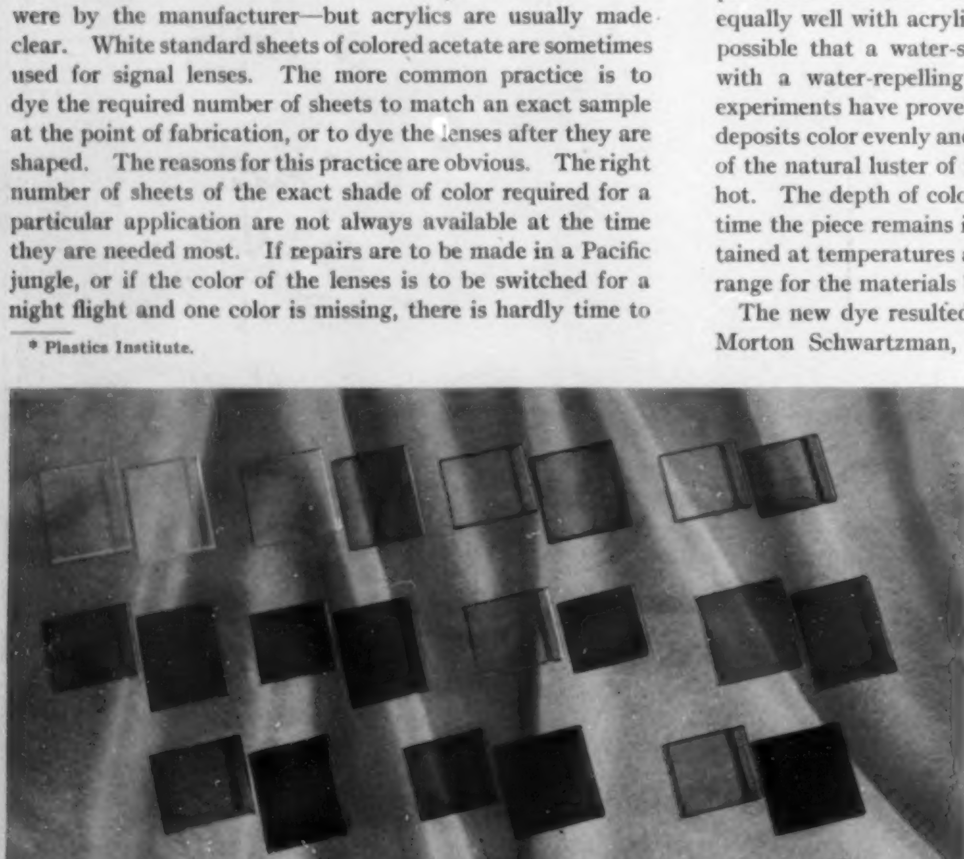
Dyeing clear plastics is by no means new. Wherever colored acrylics are employed, they are usually dyed, because it has been found utterly impracticable to try to make available a range of colored transparent acrylics in the many thicknesses required to meet the needs of industry and decorators everywhere. No matter how many colors were prepared, someone would always want a different shade. Tremendous stocks would be necessary, and many of the colors would be inactive and perhaps change with age. Nor is such a procedure necessary since very good dyes are on the market.

These dyes are usually applied from a solution in acetone diluted with water, which reacts favorably with acrylics so as to disperse an even color over the entire surface of the piece being dyed. However, acetone dyes must be used with extreme care because acetone, being a solvent, is liable to attack the surface causing it to *blush* (or haze) and also to craze.

Now, strange as this may seem, a new water dye has been perfected and will soon reach the market, which works equally well with acrylics or acetate sheet. It hardly seems possible that a water-soluble dye can be made compatible with a water-repelling plastic material like acrylic, but experiments have proved that it can. Furthermore, this dye deposits color evenly and permanently without destroying any of the natural luster of the surface, even though it is applied hot. The depth of color may be controlled by the length of time the piece remains in the hot bath. Best results are obtained at temperatures and time limits well within the safety range for the materials being dyed.

The new dye resulted from research by a young chemist, Morton Schwartzman, who has (*Please turn to page 164*)

* Plastics Institute.



Lenses of clear acrylic or acetate plastics can be treated on the spot, with this water-soluble dye, thus facilitating signal light repairs in remote battle areas. The accompanying illustration, showing sections of plastic sheet dyed by this method, suggests the unlimited variety of shades obtainable

PHOTO, COURTESY U. S. SIGNAL CORPS. 1

1—These portable x-ray units are transported by jeep to advance hospital or Red Cross installations where they are often unloaded under fire. 2—This assembled field x-ray unit shows the basic control knobs and plastic timer

The portable x-ray field unit

PHOTOS, COURTESY PICKER X-RAY CORP.

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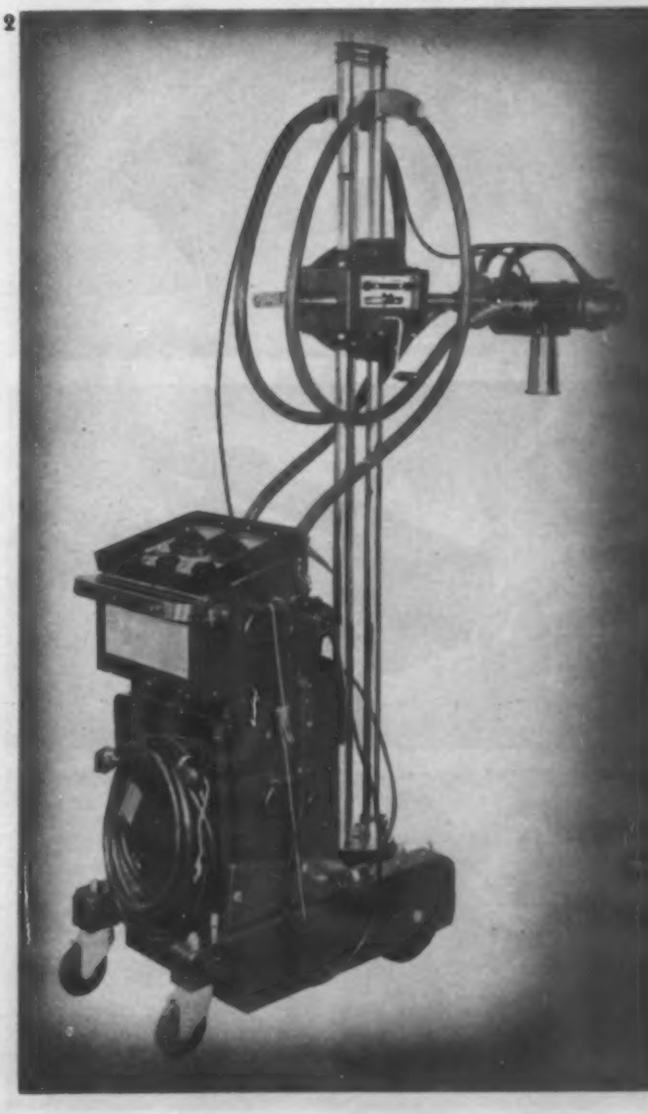
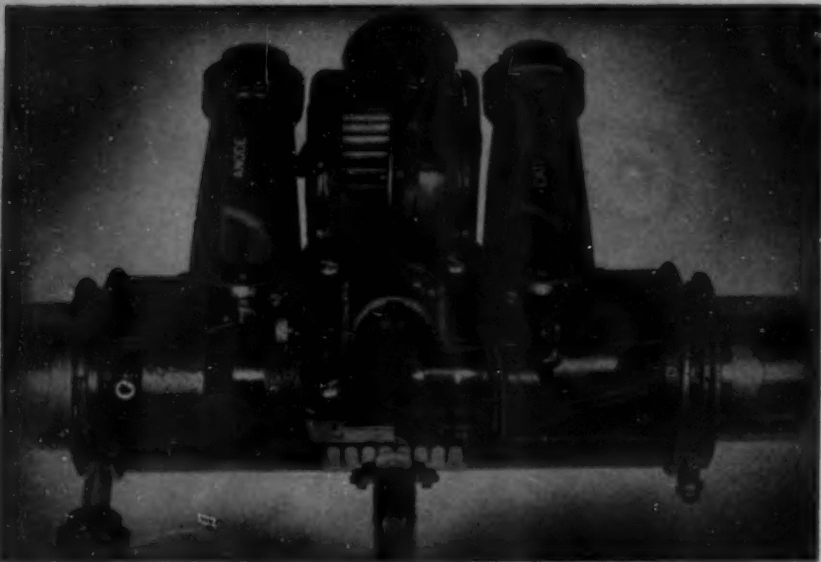


TODAY many pieces of war equipment engineered wholly or in part for plastic materials serve a dual purpose. In addition to performing their allotted functions on the battlefield or behind the lines, they aid designers in selecting the correct materials for their postwar industrial products. One such example of properly engineered plastics is the Picker portable x-ray unit which is furnished to our Armed Forces.

This piece of equipment may be packed in three Carlisle chests (one of which is shown in Fig. 1) and, insulated against shock and protected from moisture, carried by jeeps or even dropped from planes to advance hospital or Red Cross installations. With its own power plant, in a matter of minutes, the complete x-ray unit (Fig. 2) may be set up and put into operation. Front-line hospitals all over the world now have a new and efficient device which helps to reduce fatalities and permanent disabilities among our fighting men. This unit, which incorporates the most advanced designs, may be operated continuously because it is equipped with a special blower and ventilating ports which prevent overheating during periods of hard usage. Produced on a large scale, thousands and thousands of these versatile instruments are in active war service today.

But let us see how Picker x-ray engineers have called upon plastics to aid them in the construction of the head (Fig. 3) of this light, tough, efficient piece of apparatus. It is most important to note that a wide variety of plastics were selected. Because each part differs in its requirements and features of design, each distinct material specified for a certain part has properties essential for that particular application. Actually the following 11 different types of plastics are used in the head of the instrument:

1. Clear phenolic
2. General-purpose, woodflour-filled phenolic
3. Medium low-impact phenolic
4. Medium-impact, rag-filled phenolic
5. High-impact, rag-filled phenolic (*Please turn to next page*)



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3—*This cutaway view of the head of the portable x-ray unit shows the numerous plastic parts used in its construction.* 4—*To leave the machine, the rays must pass through this port, or transparent lens.* 5—*This cone- and filter-supporting block must have great strength to support the heavy lead-lined cone which can be seen in Fig. 2.* 6—*The high-voltage lead-in socket is molded of 3 different types of phenolic material.* 7—*This scale housing is used in focusing the x-ray unit*

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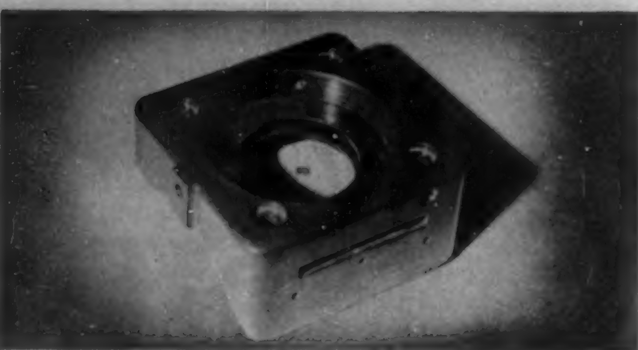

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6. Mica-filled, low-loss phenolic
7. Phenolic-paper laminated tubing
8. Cast phenolic
9. Urea
10. Polystyrene
11. Cellulose acetate

And these 11 types of plastics are molded or formed by six different fabrication methods, namely:

1. Compression molding
2. Transfer molding
3. "Offset" molding
4. Laminating
5. Injection molding
6. Casting or pouring

The x-ray port (Fig. 4) through which the ray must pass as it leaves the machine is perhaps subject to the widest variety of requirements. Transparency, necessary to permit inspection of the x-ray tube, is as essential as the fact that the part must resist hot oil since it seals off the entrance from the oil-radiator system used for even cooling. This port must, therefore, retain its critical dimensions over a wide temperature range and, at the same time, be resistant to shock. Mounted as it is in the center of the unit, the x-ray port must have excellent dielectric strength, be both concentric and of uniform thickness, and be molded with optical precision. A transparent phenolic, molded by the compression process, was selected as the one material having all the desired properties. It is also important to note that this material does not break down under the terrific impact of the x-rays which can disturb molecular structure of many plastic materials.

Perhaps the next most critical part of the x-ray head is the port-, filter- and cone-supporting block which is transfer molded of fabric-base medium-impact phenolic molding material. Figure 5 shows this molded block. Savings in weight and in machining time are obvious. The slot on the side of the piece is molded-in and permits the filter to be slipped into place easily. Due to the design of the cores necessary to mold the filter slot in place, it would have been virtually impossible to mold this piece by any other than transfer molding, where the mold is closed before the material enters. The block must also be strong enough to support the lead-lined cone shown in Fig. 2. This piece is clearly seen in the cutaway illustration (Fig. 3), where the x-ray port and filter also are shown in place in center of assembly. (*Please turn to page 180*)

New high-temperature styrene

by C. L. JONES, JR., and M. A. BROWN, JR.*

RESEARCH work on a new thermoplastic molding compound of markedly improved heat resistance has led to the development of a new plastic, polydichlorostyrene. The compound is related to polystyrene but differs in properties, applications and manufacturing methods. However, the moldability and other advantages of polystyrene are retained in this new material.

Since their introduction about 15 years ago, thermoplastics have labored under the handicap of low heat-resistance characteristics when compared with thermosetting plastics or other materials. The highest A.S.T.M. heat distortion point reported for any thermoplastic is 214° F., and virtually all values over 200° F. represent special formulations not suitable for general use. Despite this handicap, the use of thermoplastics has grown enormously. However they have been excluded from three important classes of applications—those involving contact with boiling water, those intended for use in radio and other electronic instruments operating at elevated temperatures, and those general industrial applications that involve moderately high operating temperatures. The importance of opening these fields to thermoplastics is apparent.

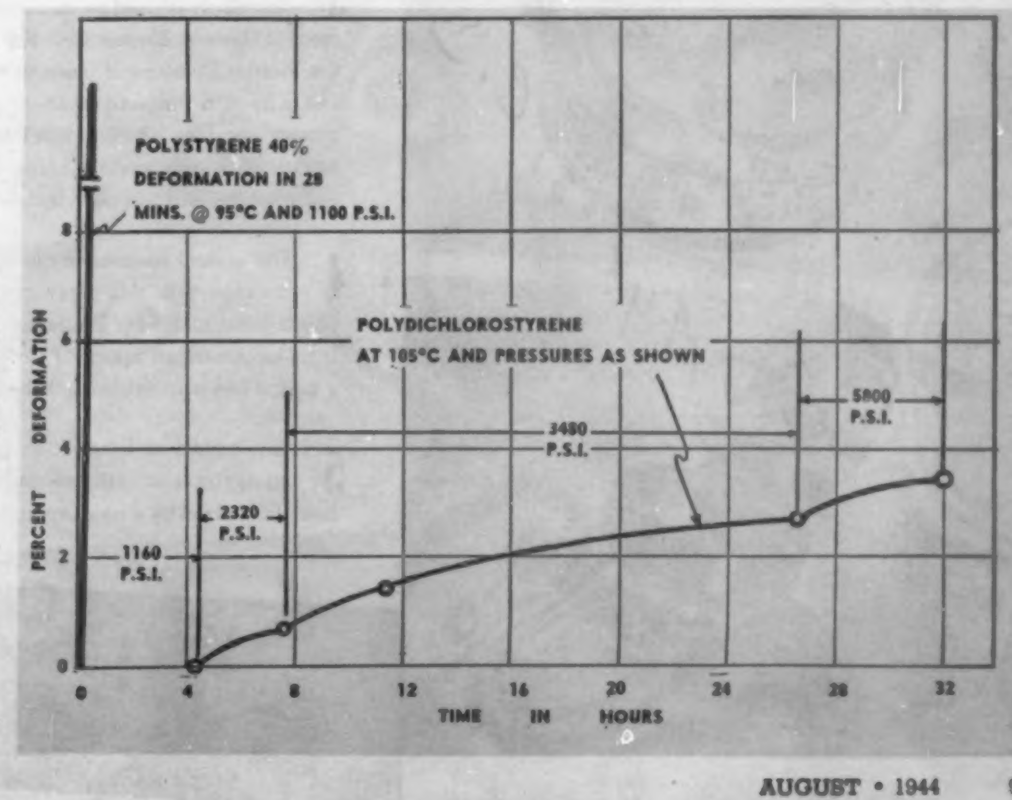
In the past this problem has been attacked through modification of known plastic compounds by selection of plasticizer or modifying agents, or by treatments subsequent to molding. These steps have only been successful in raising the heat distortion points in a narrow range. In the case of polystyrene, a compound modified by the addition of chlorinated diphenyl varnish and lacquer resins resulted in the development of Styramic[1] with a heat distortion point about 15° F. better than polystyrene. This material has found limited but important use in electronic applications because it retains the high electrical insulating properties of polystyrene. However, Styramic was only a step in the desired direction since its heat distortion point falls short of the boiling temperature of water and is still too low for certain types of electronic applications.

During the war, laboratory work has continued along this avenue of research because of the military applications that can be filled only by high-temperature thermoplastic compounds which retain high electrical insulating properties. One approach has been the chemical modification of the styrene molecule. This has resulted in the production on a pilot plant scale of a plastic product which has been designated as Styramic HT, chemically, polydichlorostyrene.

Polydichlorostyrene is projected as a material of high heat resistance retaining in full, or slightly improving upon, the electrical insulating characteristics of polystyrene, which are well known. Cost of manufacturing this material is fairly high, and it is expected that it will be a somewhat specialized product for use where its relatively high cost can be justified by the electrical and mechanical properties that it makes available. Polydichlorostyrene was placed on allocation by the War Production Board on Feb. 1, 1944. The small amount of this material available is being allocated directly for essential war applications and experimental work.

An A.S.T.M. heat distortion point of 236° F. is the most important physical characteristic of this material. Deformation characteristics under load are given in Fig. 1 and provide design data on safe top operative temperatures. Dimensional stability is further assured by a water absorption value of 0.03—half that of polystyrene. While overcoming the low heat resistance of polystyrene, Styramic HT has electrical characteristics somewhat better than polystyrene, which makes possible its use in ultra high- (*Please turn to page 168*)

* Plastics Division, Monsanto Chemical Co.
[1] Trade name, Monsanto Chemical Co.



1—*Deformation characteristics under load which are presented in this chart provide design data on the safe top operative temperatures*

PLASTICS IN REVIEW

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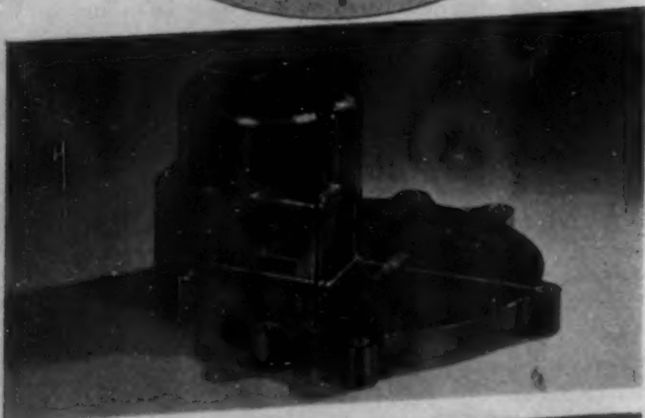

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1 To increase the efficiency of power transmission belts that turn industry's wheels, Graton and Knight Co. has perfected a tension cementing process which produces belting with uniformly high adhesive strength. In this process Celluloid plastic foil is passed through a solvent bath and fed between two single plies of leather. The 3 plies of Celluloid and leather are then fed between rubber pressure rolls and wound on a drying drum while under normal belt-drive operating tension

2 Since it is essential that a plane respond immediately to every movement of its control system, the Fairchild Engine and Airplane Corp. provided a Bakelite housing for the tab control on its Navy airplane to prevent any exterior conditions from deteriorating the mechanism. Both the top and bottom parts of this housing are molded in a single cavity die—a split mold being used for the cover, which is the larger piece. The Boonton Molding Co. molds the parts under 6000 lb. p.s.i. and cures the material on each piece for 10 minutes

3 An interesting application of Lucite is shown in this dash pot which is used in circuit breakers by the Radio Department of General Electric Co. For maximum mechanical strength the Plastics Divisions of General Electric Co. compression mold this part at a pressure of about 5 tons per square inch. The finished product, which is filled with oil when in use, is resistant to chemicals and solvents. The figures are stamped on in roll leaf after the part has been molded

4 The annual summer horde of insects can be kept at a safe distance with this spray gun equipped with a light-weight plastic head, molded of Tenite in one piece by Plastic Engineering, Inc., for American Specialty Co. A feature of this spray gun is a trough-like drip catcher attached to the spray head by a cement.

5 The hazard of fire, which presents a constant menace to pilots flying at high speeds in extremes of temperature, has been minimized by a new product of the U. S. Rubber Co. Made

5

of fabric, asbestos and a coating of synthetic resin, this fire resistant material practically eliminates the need for metal in heating and ventilating air-duct systems in aircraft. An additional advantage is its lighter weight and speed of production

6 To meet the demand for speed in airplane production, this aerial stub mast for Hawker Hurricane aircraft is now molded of Bakelite impregnated fabric. Previously these masts were machined from a solid block of laminated phenolic, but so many hours were required to machine the pieces to a teardrop design and core out the inside, that the manufacturer sought a less time-consuming method. The Joseph Stokes Rubber Co., Ltd., found that these masts were much strengthened by molding the fabric in unbroken sections

7 This Co-Ro-Lite and synthetic rubber gasoline tank fitting is an example of the application of the Columbian Rope Company's method of molding two entirely dissimilar materials in one operation. Two different bonding materials are required in this process. In the original development, called the Co-Ro-Felt pad, the center or hub is vegetable fiber impregnated with Durez phenolic resin and the outer section of vegetable fiber impregnated with a compounded latex

8 Manufacturers of many types of equipment find these hammers fitted with Nitron heads of particular value, since the plastic will not mar delicately machined metal surfaces. The heads, which are machined from rods of cellulose nitrate by Southwest Mfg. Co., screw into a metal socket

9 The next time you have the oil changed in your car, you will probably see it poured from bottles equipped with plastic pouring spouts. Molded of Tenite II by Plastic Engineering, Inc., these new blue or red spouts are designed to withstand extreme heat and cold, and the action of standard oils. By the addition of a gasket they can be made to fit all regulation mason jar type threads

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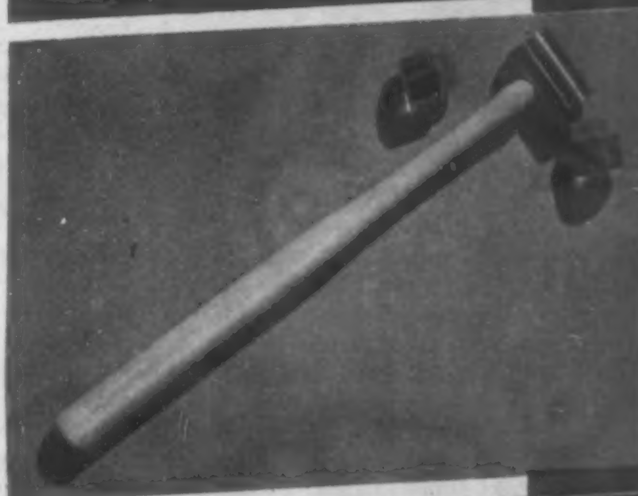

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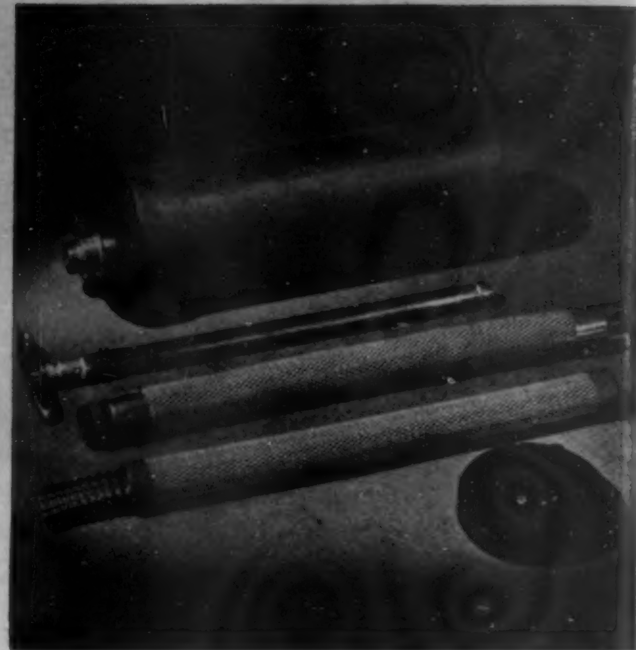
PHOTO, COURTESY SEIBERLING RUBBER CO. 1



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An emergency measure

HOUR after hour the steady throb of airplane engines fills the cabin of the patrol bomber. Eyes strain downward—on the lookout for a lurking submarine or an enemy task force. In the plane, far above the surface of the water, the security of enveloping sound is suddenly torn apart. There is an interminable second of silence. Then a sputtering, choking sound. And again, silence.

If disaster strikes once, it can strike again. And when planes are forced down, for whatever reason, there must be no chance of a second failure. For this reason the Army and Navy provide an emergency hand pump with each of their pneumatic life rafts. Since speed is of the utmost importance, these rubber boats are intended for inflation with CO_2 gas that is held under pressure in a single lightweight steel cylinder. However, there is always a danger of these gas containers being lost or damaged. In such a contingency, unless some alternate method of inflation is provided, the fliers cannot hope to keep afloat until search parties track them down. Rubber invasion boats and pontoons are also provided with compact hand pumps to insure against comparable accidents.

Two sizes of pumps are now being produced for our Armed Services. The 6-in. cylinder type employs a 12-in. hose, while the 10-in. cylinder pump is supplied with a 12-in. hose. Prior to the emergency, the barrels of these pumps were made of sheet metal. Aside from the fact that metal tended to corrode to an extent that the plungers stuck in the cylinder or were extremely difficult to operate, the metal tubing dented easily. And once dented, the pump was of no further use. This weakness was of major importance in view of the rough usage to which these pumps are subjected.

To meet existing conditions, these pumps were redesigned for plastics. The phenolic resin impregnated paper now used for the barrels is incapable of being dented. Even if the walls crack or break under a sudden severe blow, the pump can still be used. A hand clamped over the hole is sufficient to maintain the pressure within the tube. The plastic caps and plunger disks have the advantage of not corroding when subjected to salt water and extremes of weather. This is especially important in view of the fact that the life-saving equipment and the invasion (*Please turn to page 176*)

1—Although emergency life rafts are designed to be inflated with CO_2 gas, an emergency hand pump is provided as insurance that survivors will not be left without means of inflating their rubber boat should the gas container be damaged. 2—This disassembled pump shows the phenolic impregnated paper cylinder, the two phenolic caps and the extruded coil inserted inside the hose to keep it from collapsing. 3—An assembled hand pump

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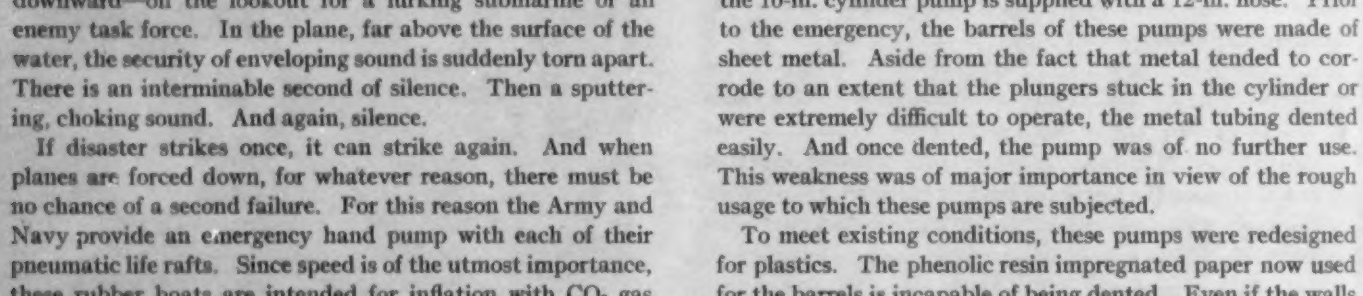


Allyl plastics*

by FRANKLIN STRAIN†

ALLYL thermosetting compounds were first introduced during 1942. The disclosure of information regarding the nature of these new plastics[1] has of necessity been restricted, due to the issuance of secrecy orders relating to specific allyl compounds. The unique properties possessed by the new materials have resulted in their use in a number of applications directly related to the war effort. In fact, uses have been confined to war applications because of limitations on the production of allyl alcohol, a raw material essential to the manufacture of the new compounds. A much more general and complete knowledge of the possibilities offered by these plastics, and an enlargement of their field of applications, appears certain when restrictions are lifted.

The thermosetting allyl plastics differ fundamentally from the older thermosetting materials in the type of reactions involved in curing. In general, monomer addition-polymerization reactions are involved, activated by peroxide catalysts and producing no gaseous or other by-products. The allyl compounds, as representative of a new class of thermohardening materials cured by addition-polymerization, resemble the thermoplastic resin-forming monomers in polymerization characteristics, but are similar to the older commercial thermosetting compounds in properties of the final polymers.

The absence of volatile products of polymerization, together with the low viscosity and the penetrating qualities of certain of the allyl compounds, make these plastics well suited to the impregnation of porous materials. Desired effects that may be produced include reduction of porosity, increase in resistance to solvents and to deteriorating influences, and reinforcement of the strength of the plastic. Reinforcement of the compounds with fibrous base materials for the production of laminates by very low- or contact-pressure methods has constituted an important application.

* Abridged from a paper presented at the A.S.T.M. Symposium on Plastics held in Philadelphia, Pa., on Feb. 22–23, 1944, and published here through the courtesy of the American Society for Testing Materials.
† Columbia Chemical Div., Pittsburgh Plate Glass Co.
[1] Modern Plastics *20*, 88 (Oct. 1942); ibid. *20*, 101 (June 1943); ibid. *21*, 95 (Nov. 1943); Plastics Catalog, 143 (1944).

Since the application of pressure is unnecessary during curing, except for maintaining the desired form of the composite, very low pressures of the order of zero to a few pounds per square inch may be employed. These low pressures make possible the fabrication of large laminated structures of complicated shape, such as aircraft parts.

Physical test data correlating changes in the properties of the allyl plastic laminates with changes in the properties of the cast plastics, show that the nature of the fibrous reinforcing agent largely controls properties such as tensile strength and impact resistance. On the other hand, other significant properties such as compressive and flexural strengths and solvent resistance, are strongly influenced by the plastic matrix. Therefore, these latter properties of the laminate may be emphasized by the tailoring of the polymer. The combination of polymers developed in this way when glass fiber fabrics are used as the reinforcing agent has resulted in composites which are superior in certain mechanical properties to the light metals and alloys.

The types of allyl plastics thus far developed have included primarily liquid monomers and their polymerization products in the form of a) transparent castings, and b) laminates. Other types, now in the experimental stages, are being developed for such applications as protective coatings.

Properties of allyl plastics

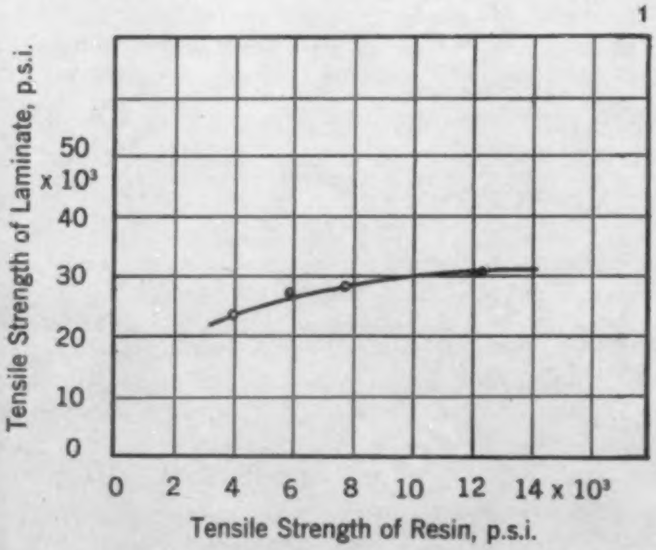
Test data showing properties of several of the Allymer[2] resins in the forms of cast sheets and laminates which are prepared using different base materials, are given in Tables I and II, and in Figs. 1 to 7. A.S.T.M. methods were followed in the determination of water absorption (D 570–42), resistance to chemical reagents (D 543–43), thermal conductivity (D 325–31 T) and plastic yield (D 621–43).

Procedures conformed to the Federal Specification for Plastics, Organic, L-P-406a, in the following tests except as

[2] Trade name, Pittsburgh Plate Glass Co. This name is now applied to the class of materials formerly called Columbia Allyl Resins.

1 and 2—These two charts show the correlation of tensile strength and modulus of rupture properties of cast allyl resins with those of allyl resin heat-cleaned ECC-11-128 glass fiber crossed laminates

1



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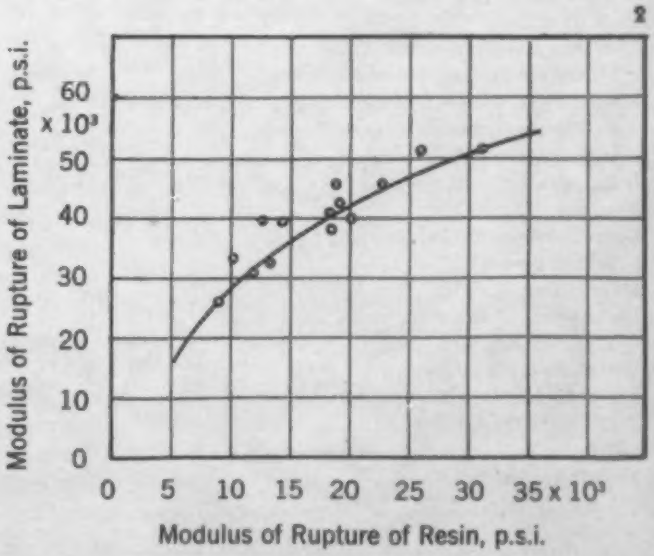


TABLE I.—PROPERTIES OF CLEAR CAST ALLYMER RESINS

Properties of polymer	*Allymer C.R. 39-1*	*Allymer C.R. 39Bd*	*Allymer C.R. 149*
Specific gravity, 25° C./4° C.	1.31	1.38	1.34
Refractive index, 20° C.	$n_D = 1.50398$	1.51	1.52
	$n_C = 1.50131$	...	...
	$n_F = 1.51002$	...	...
Dispersion factor, $n_D - 1/n_F - n_C$	57.84	...	...
Hardness			
Knoop	11–14	16–19	19–22
Barcol impressor, 15 sec.	26–30	38–42	48–54
Rockwell-M scale	95–100	110	117
Cold flow			
Barcol impressor, 15 sec.	8–11	4–5	4–6
Plastic yield, 1000 lb., 1/2-in. cube			
Room temperature, in.	0.006	0.002	0.003
+50° C., in.	0.022	...	...
Abrasion resistance			
Mar resistance			
Taber × methacrylate	30–40	20–30	18–25
Falling emery × methacrylate	8–10	5–8	3–5
Falling emery × glass	1.2–1.4	0.7–1.0	0.7–1.0
Wear resistance	2–3		...
Tensile strength, 25° C., p.s.i.	5000–6000	7000–9000	...
Modulus of rupture, p.s.i.			
50° C. (122° F.)	5000–6000	11,000–14,000	...
25° C. (77° F.)	8000–10,000	20,000–25,000	26,000
−10° C. (14° F.)	13,000–15,000	...	...
−57° C. (−70° F.)	14,300	...	...
Modulus of elasticity in flexure, 10^5 p.s.i.			
50° C. (122° F.)	1.6–2.0	2.0–2.5	...
25° C. (77° F.)	2.5–3.3	4.4–4.7	5.5
−10° C. (14° F.)	3.7–4.0	...	...
−57° C. (−70° F.)	3.4	...	...
Compressive strength			
Ultimate, p.s.i.	22,800	25,000–27,000	26,000
Modulus, 10^5 p.s.i.	2.3	3.0–4.0	4.0
Impact strength, 25° C. ft.-lb. per in.			
Izod, notched	0.3–0.4	0.3–0.4	0.6
Charpy, notched	0.3–0.4	...	...
Izod, unnotched	2–3	4–6	3–4
Charpy, unnotched	3–4	5–8	...
Specific heat, cal./g. ° C.	0.55	...	...
Thermal expansion linear coeff., 10^{-5} per ° C.			
−40° C. to −10° C.	7.0	...	...
−10° C. to +25° C.	8.7	...	...
25° C. to 50° C.	10.7	...	...
95° C. to 120° C.	15.3	...	...
Thermal conductivity			
10^{-4} cal./sec. cm./° C.	5	...	...
Btu./hr./ft.^{2}/in./° F.	1.45	...	...
Heat distortion			
10 mils distortion temp., ° C.	55–70	95–105	65–70
Distortion at 130° C., mils	35–65	25–35	175–190
Maximum recommended operating temp. under no load[a]			
Continuous service	100° C. (212° F.)	135° C. (275° F.)	100° C. (212° F.)
Intermittent (1 hr. duration)	150° C. (302° F.)	...	150° C. (302° F.)
Burning rate, 1/8-in. sheet Navy test, in. per min.	0.3	0.5	0.4
Warpage	0.00	...	...
Light transmission before aging			
White, percent	90–92	...	...
Haze before aging	1–2	...	...
Light trans. after aging			
White, percent	89–91	...	...
Water absorption, percent	0.2–0.4	0.2	0.2
Power factor			
1 Kc	0.012	...	...
1 Mc	0.057	...	...
Dielectric constant			
1 Kc	3.8	...	...
1 Mc	3.6	...	...

Table I.—Properties of Clear Cast Allymer Resins (*Continued*)

Properties of polymer	*Allymer C.R. 39-1*	*Allymer C.R. 39Bd*	*Allymer C.R. 149*
Dielectric loss			
1 Kc	0.047	...	...
1 Mc	0.20	...	...
Dielectric strength, 1/16-in. thick specimens			
Short time, volts/mil	570	...	...
Step by step, volts/mil	525	...	...
Resistance to chemical reagents, gain in weight after 7 days' immersion, percent			
Distilled water	0.7	0.7	0.5–0.7
30 percent H_2SO_4	0.5	...	...
3 percent H_2SO_4	0.7	...	...
10 percent HNO_3	0.7	...	...
10 percent HCl	0.4	...	...
10 percent NH_4OH	0.8	...	...
10 percent NaOH	0.5	...	...
1 percent NaOH	0.6	...	...
2 percent Na_2CO_3	0.6	...	...
1 percent NaCl	0.6	...	...
3 percent H_2O_2	0.7	...	...
95 percent ethyl alcohol	0.1	...	...
50 percent ethyl alcohol	0.5	...	...
Acetone	0.5	0.4–0.6	0.2
Ethyl acetate	0.3	...	...
Carbon tetrachloride	0.6	...	...
Chloroform	1.5	0.6	...
5 percent acetic acid	0.6	...	...
Gasoline	0.1	0.1	...
Oleic acid	0.2	...	...
Benzene	0.7	...	...
Toluene	0.6	...	...

[a] Under special conditions, such as the inner panel of a heated-air de-icing window, Allymer C.R. 39-1 has performed satisfactorily over long periods with 240° F. air on one surface and room temperature air on the opposite surface.

otherwise indicated: Rockwell hardness, tensile strength, modulus of rupture, modulus of elasticity in flexure, compressive strength, impact strength, Johnson shear strength, constant-strain flexural fatigue strength, thermal expansion, flammability, distortion under heat, accelerated weathering, light transmission and haze, falling emery mar and Taber abrasion resistance, dielectric constant, power factor, dielectric loss and dielectric strength.

In the determination of falling emery mar resistance, the plastics were abraded by letting weighed amounts of No. 60 emery fall from a funnel through a vertical tube, 6 ft. long and 1 in. in diameter, upon the specimens held at an angle of 45°. Abraded specimens were compared visually and the abrasion values were expressed in two ways:

1. $$\frac{\text{Weight of emery used to abrade specimen}}{\text{Weight of emery needed for equivalent abrasion of glass}}$$

2. $$\frac{\text{Weight of emery used to abrade specimen}}{\text{Weight of emery needed for equivalent abrasion of methacrylate}}$$

The Taber method specified in Federal Specification L-P-406a was modified for measuring mar resistance to the point of failure for glazing applications as follows: The specimens were abraded with the Taber abraser, using a CS-10 wheel, after which the abrasion patterns were compared visually with those on a standard methacrylate sample abraded, using 5 revolutions of the abraser. The abrasion values were calculated as:

$$\frac{\text{Revolutions needed for equivalent abrasion of specimen}}{\text{Revolutions used for methacrylate sample}}$$

In measuring wear resistance, the weights of plastic removed by the Taber abraser, using a CS-17 wheel, were compared at high extents of abrasion (1000–5000 revolutions). In the heat distortion test the observations were continued until 130° C. was reached, in order to obtain added information on the thermoelastic behavior of the plastics; the weight applied to the sample was adjusted for variation in thickness of the test specimen in this test. In measuring the compressive strength of the clear cast polymers, the dimensions of the test specimens were reduced. These specimens consisted of a pile of sheets 1/2 in. square with a minimum number of layers to produce a height of at least 1/2 inch.

Knoop hardness was measured following the procedure outlined in National Bureau of Standards Research Paper RP1220. In measuring the Barcol hardness and cold flow, the dial readings of the instrument[3] were noted as soon as the load was applied to the point and again 15 sec. later. The latter reading was recorded as hardness, and the difference between the two as cold flow. The test for warpage due to elevated temperature followed the Navy Aeronautical Specification P-41C, Sec. F-3i. The bonding strength of laminates was determined according to the Bureau of Ships method 17R5 (INT) of May 1, 1940. Test measurements were made in one of the directions parallel with the machine direction of the plies in the case of paper-base laminates; parallel with the warp threads for fabric-base laminates; and at right angles to the above-mentioned directions if all of the plies were oriented with the directions parallel.

Haze values (Figs. 3 and 6) were determined through the use of the hazeometer exactly as in (*Please turn to page 168*)

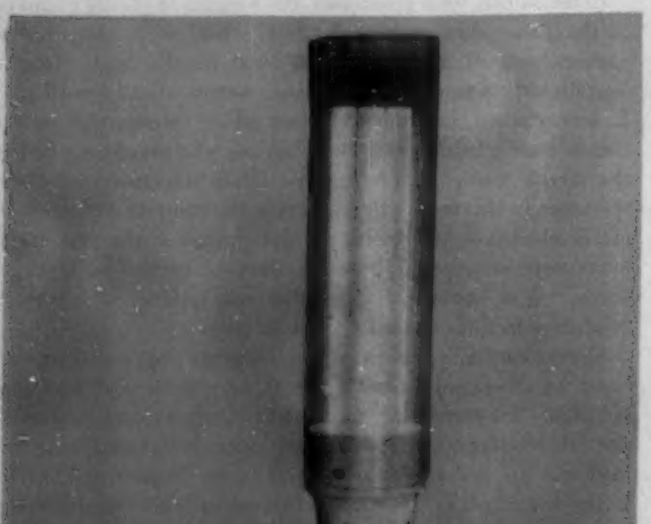
[3] Barber-Coleman Co.

THE EFFECTIVENESS OF NIGHT BOMBING DEpends partly on the element of surprise. While motors cannot be silenced, planes can fly at sufficient altitude to lessen the sound of their approach. But light will betray the presence of raiders even at extreme heights—especially when it is silhouetted against the blackness of a moonless sky. Yet, to fly without some illumination of the controls is not always practicable. Therefore, cockpits have been equipped with lamp reflectors which control the direction of the lamp's rays, diffuse them and, when necessary, preclude the emission of all light.

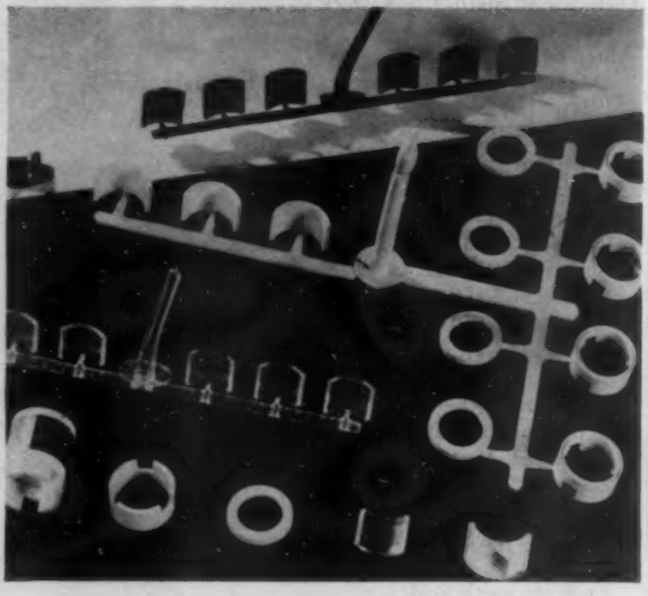
Known as cylinders, these 5-piece reflectors fit into special cases in which they revolve. Depending upon the requirements of the moment, they may be turned to emit either a white light, or a red light possessing a specific wave-length property, which will mask the light while yet enabling the pilot to see the complicated mechanism of his instrument panel. If all light must be extinguished, the reflector may be turned to an opaque white section which completely shuts off the stream of light.

As can be seen in the accompanying illustration, parts for 3 complete lamp housings are molded at one time. The red and the clear windows are each molded in 6-cavity dies. These lamp reflectors for the cockpits of B-7's must be held to close tolerances, and the assembly must come to within 0.005 of exact indexing. Such precise measurements, maintained throughout the molding of the 5 component parts of the reflectors, illustrate the ability of some thermoplastics—in this case, polystyrene—to meet the most stringent dimensional stability requirements which may be set up by manufacturers of wartime equipment.

Credits—Material: Bakelite polystyrene. Molded by Franklin Plastics Div., Robinson Industries, Inc., for Pittsburgh Reflector Co.



PLASTICS PR



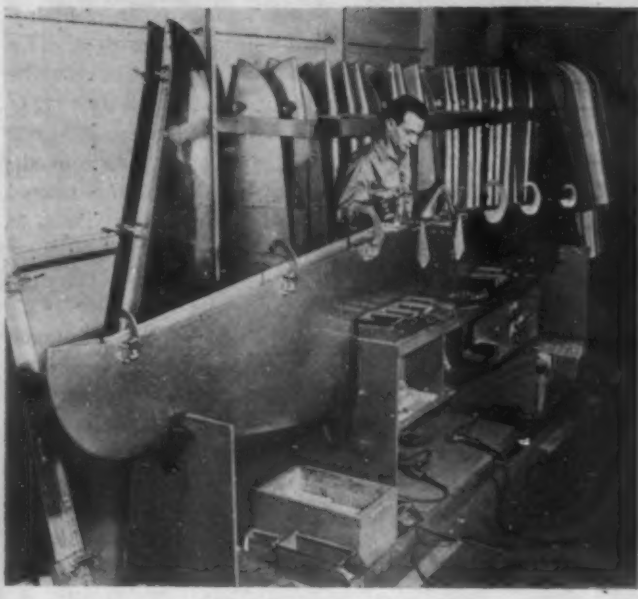
EACH INTRICATE PIECE OF MACHINERY IS THE final product of a careful interpretation of the engineer's blueprint. Since everyone is not equipped with 20-20 vision, material aids must be supplied to guarantee the reading of every fine detail of these highly complex drawings. One manufacturer has met this need in the production of "Tube-A-Lites"—powerful lamps that can be affixed to a stand immediately above or below the drawing, or held in flashlight fashion in the reader's hand, depending upon the immediate preference of the user. This latter method of handling is shown in the accompanying illustration.

As originally designed, the lights consist of three 6-watt fluorescent tubes, 9 in. in length, arranged in a circle around a central supporting phenolic laminated tube, and enclosed in an envelope of transparent methyl methacrylate. This envelope is cut to size from regular standard lengths of tubing which are supplied by the fabricator. Current WPB restrictions may restrict the number of fluorescent tubes in the light to two. The base, head and switch housing are fabricated of phenolic laminated tubing or sheet stock, bolted or screwed together. A completed lamp measures $15^{1}/_{2}$ in. in length and $2^{3}/_{4}$ in. in diameter. These units are designed to operate on a currency of 110 volts, 60 cycles.

A separate mechanical type starting switch is supplied for each fluorescent tube so that the user may turn on as much or as little light as is necessary. The apparatus is so arranged that it can be opened easily for the insertion of new tubes. Ballasts are enclosed in a separate compartment which is equipped with a chain for ready suspension near the plug-in, and are connected to the light by means of fifteen feet of cable. For convenience in handling, a break-type ring is attached to the end of the lamp switch, and the switch housing is so shaped as to form a handle if the light is to be carried as a flashlight.

Credits—Materials: Formica tubing and sheeting, and Lucite. Manufactured by the Larrimore Sales Co.

PRODUCTS



WITH TRANSCONTINENTAL AND TRANSOCEANIC flights becoming the rule rather than the exception, reservoirs of supplies become immediate necessities, especially over barren stretches of land or vast expanses of water. Such reserves may bulk large in the supply compartments or, as in the case of lubricants for landing gear brake systems, may occupy only a very limited space. Yet, the need for both is equally important, especially when an adequate supply of the latter may mean the difference between a three-point landing and a crack-up.

Brake fluids are housed in a tank which is filled to the level of the threaded joint. Through a hose connecting the tank with the master cylinder, the tank acts as a replenishing chamber. The cap of the tank acts as an expansion chamber, enabling the fluid to adjust itself to the narrower confines of the hose and flow more smoothly. Further control is effected by means of a fine mesh screen which rests on the shoulder at the base of the tank, serving as a filter to prevent any foreign material present in the lubricant from entering the brake system.

To enable the service personnel to check readily the quantity of reserve fluid available, a transparent material was specified in the construction of the tank, which would have good wear resistance and be able to withstand extremes of temperature. Consequently, clear cellulose acetate butyrate was chosen. This material is injection molded in a two-cavity mold to form the tank proper, the threads of which are molded in with the body. It is also used for the cover which is formed in a two-cavity mold and gated at the center. The molded threads of the cover have an automatic unthreading attachment. The insert in the base of the tank provides a harder material for the mounting and for the threads which receive the hose.

Credits—Material: Tenite II. Molded by American Insulator Corp. for Bell Aircraft Corp.

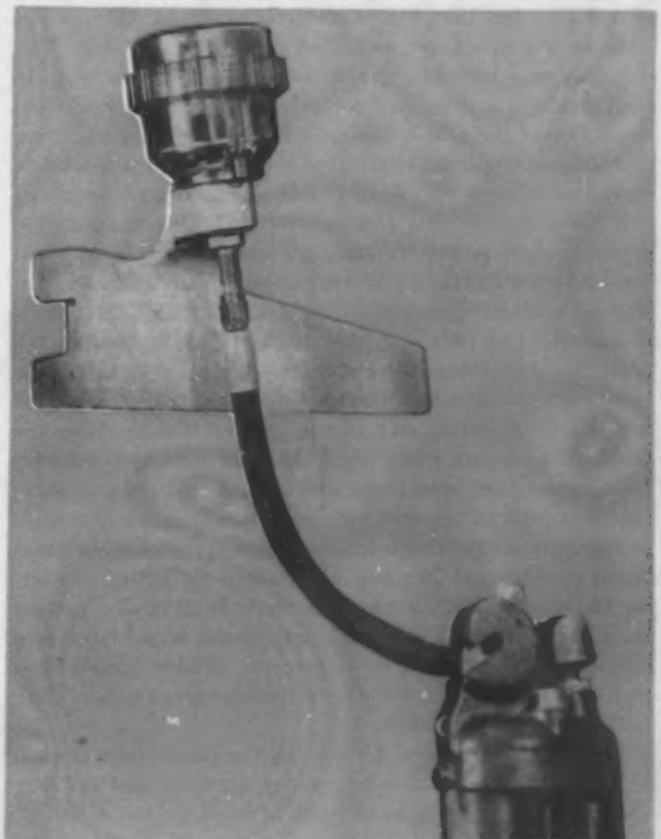
* Reg. U. S. Patent Office.

IN HEAD-ON CONFLICT WITH THE ENEMY, A PILOT must have complete command of his ship, so that each maneuver of defense or attack can be executed the moment the need for it arises. For example, the tail plane, or stabilizer, which is the primary control organ of an airplane, lies at the extreme rear of the plane, yet it responds to the slightest pressure of the controls. Measuring only one-ninth of the wing area, the stabilizer balances the plane in steady flight, trims it for various speeds, controls the rate of climb or descent and causes it to dive, if necessary. It consists of two parts: the front or normally rigid section, and the rear or elevator, hinged on an axis, with a trailing edge which can be raised or depressed.

Wartime stabilizers of the Vultee B-13-A are constructed of a one-piece molded plywood skin, formed of two face plies and one core ply, mounted on a tail-plane structure. Each of these plies is first edge jointed; then a synthetic resin adhesive is applied to the edges. After this glue dries, the veneers are trimmed roughly to size. Since the veneers run at a 45° angle to the leading edge of the skin, short pieces are needed on the ends of the skin.

After each ply is spliced, it goes to the router table and is stacked on the preceding ply until 20 deep. The router pattern is then put in place and the plies routed to finish size. A phenol-formaldehyde resin adhesive is brushed on to each face of the flat core ply and the ply hung up to dry—care being exercised to keep the sheets from curling. After drying, the core ply is sandwiched between 2 face plies and pinned on a form block which has first been covered with cellophane. A rubber bag is placed over the form, the end sealed up and a vacuum drawn over it. The assembly is then baked in an autoclave at 300° F. and 60 lb. pressure.

Credits—Resin adhesives: Lauxite and Amberlite. Molded by Kroehler-Doak Aircraft Parts Div., Kroehler Mfg. Co., for Consolidated Vultee Aircraft Corp.



The economy of gold

OLD adages about the dearest being the cheapest in the long run were again proved true by chemists of the Eastman Kodak Co. when they developed a new method for the rapid production of assembly fixtures of a phenolic liquid casting resin.

Eastman accepted a Government contract to produce an essential and urgently needed war part. In order to produce this part in the quantities required, several hundred assembly jigs or fixtures were needed in a great hurry. Precedent dictated production of the fixtures by the most generally accepted method, which demanded the services of hundreds of expert tool makers, thousands of pounds of tool steel, and tens of thousands of man-hours. By this method, months would have been consumed before actual assembly of the part could even have been started. But the company's Camera Works Laboratory was not bound by precedent. Its chemists believed that these fixtures could be molded of a phenolic casting resin, and that the time needed to produce the plastic fixtures would be considerably less than that consumed by any other method.

Backing the courage of their convictions with action, the company engineers built a test mold of steel. In cooperation with technicians of the plastics materials manufacturer, they produce the first fixture. This casting was perfect. The fixture was held to the exceptionally close tolerance of ±.001 inches. A time study proved that about 6 fixtures could be produced every 5 days from the one mold. But time was still an important factor. Even this production schedule was not fast enough because the ultimate parts were wanted at the war fronts immediately.

The problem of stepping up production beyond this point by means other than the manufacture of more steel molds, which would have taken weeks, seemed insurmountable. The difficulty was twofold. When casting the phenolic resin in steel molds, it is necessary not only to protect the steel from the action of the acid in the resin but also to have a coating on the mold to permit removal of the cast resin. Customary procedure is to employ some one of several organic coatings.

If close dimensional tolerance is to be maintained, the application of protective coatings must be made with extreme caution so that a uniform film will result. In many instances, such an application is not possible unless the mold is disassembled for coating. After the casting is made in such a protected mold, more often than not the lining is broken or completely destroyed by the removal of the cast resin. This necessitates recoating and, in many cases, disassembling the mold for recoating when more than one casting is desired. Such a procedure, when resins are cast on a production or semi-production basis, becomes very costly and consumes time.

The company's chemists and engineers again put their heads together. If they could find a new method of protecting the steel and at the same time have it serve as a parting agent, they believed they could reduce the actual labor production time of a fixture by 75 percent. Within a week these men found the answer, and a simple one it proved to be. They gold-plated the steel mold.

A steel mold was used for making the plastic part of casting resin because it afforded greater accuracy and stability than any other type of mold (such as wood, plaster or latex). The protective coating of gold plate permits the utilization of these properties of steel molds and simultaneously delivers lower unit cost per casting. Gold, being a noble metal, is resistant to all acids except, of course, aqua regia (nitrohydrochloric acid). Therefore, it is ideally suited as a protection for steel molds used for casting resins. Multiple castings may be made from gold-plated molds without the cost and time lag of re-preparing the mold for each new casting. As soon as one casting is removed from the mold, another may be immediately poured and cured. In molds where the resin is poured about a plug or core, it is advisable to wipe a wax (such as Johnson's Wax No. 156, 10 percent) as a lubricant on these parts. This is to keep the gold from wearing when the castings are removed from the parts.

The time and labor saving made possible by the use of gold plate instead of organic coatings is considerable. For example: company engineers are now casting plastic parts from a gold-plated mold in 3 hours, consuming one-half hour of labor. The same mold, if protected by an organic coating, would require 15 hours' time and 5 hours' labor to prepare. This includes disassembling, stripping, spray-coating, drying and baking, reassembling and molding. Inasmuch as this mold is held to ±.001 in. on critical dimensions, an under or over thickness of paint film would alter the usefulness of the mold. From a gold-plated mold, identically dimensioned parts can be produced.

The gold plating of the mold follows a preliminary copper plate and a nickel plate. The thickness of the plating was controlled so that it did not interfere with the desired dimensions of the completed cured casting. The plating operations are as follows:

	Inches
Copper plate..........................	.0003
Nickel plate..........................	.0001
Gold plate (Wittenberg process).........	.0001 (max.)

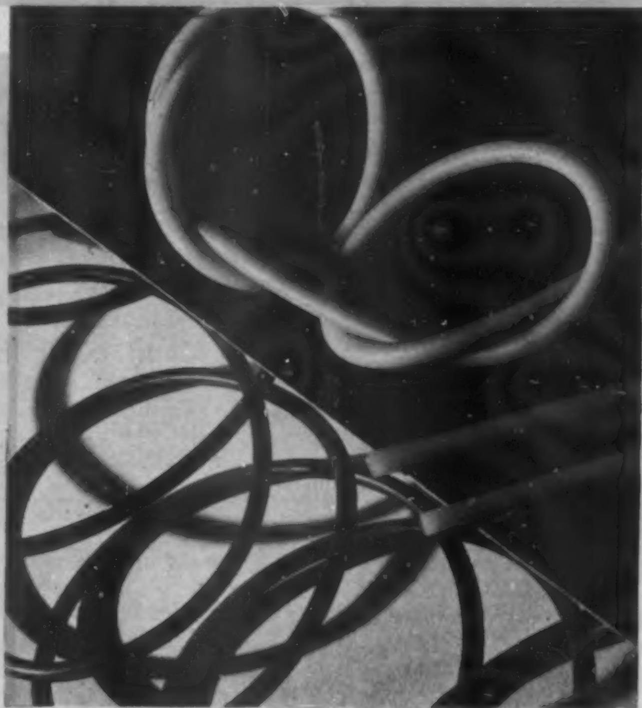
A better plating was secured by disassembling and plating the mold in individual parts. Surfaces which did not come in contact with the casting resin were masked off for the gold-plating operation. The cost of gold of .0001-in. thickness is approximately 13 cents per square inch. On the mold referred to above, the gold plating cost was less than $200.

The use of the phenolic casting resin in place of another material eliminated many machine operations. The resultant saving justified the use of gold plate. However, as previously pointed out, the closer adherence to dimensions, lower costs and faster production credit the use of gold plating with its own economy.

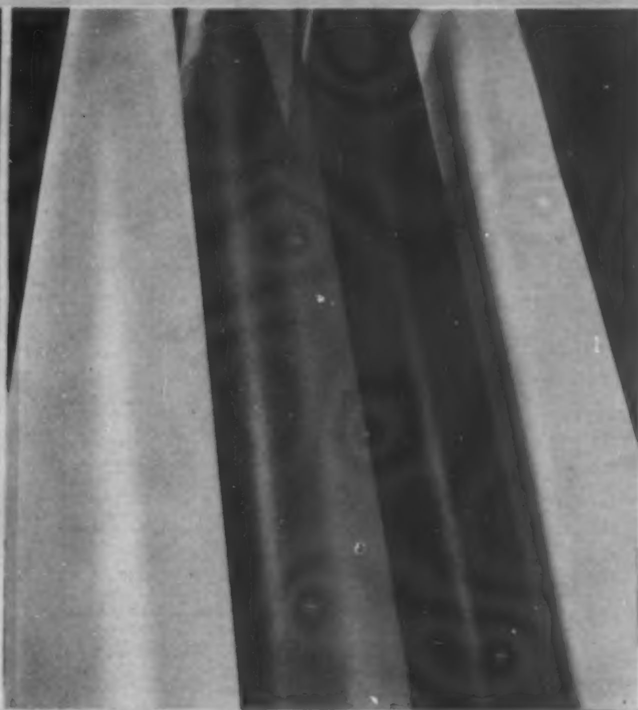
The 3-hour schedule which the company engineers established was made possible by several short cuts in the use of the casting resin as well as by employing the gold plate. These include heating the mold before pouring, heating the resin before mixing and pouring, and immediate heat curing after pouring. It was the use of gold plate, however, that cut the bulk of the 15-hour schedule to 3 hours.

This new-found method has not only resulted in the saving of untold man-hours and dollars but will further speed our war production because it is being made available to industry. Its postwar value is at present immeasurable.

Credits—Material: Durez casting resin. Gold plating by Eastman Kodak Co.



1 ALL PHOTOS AND DRAWINGS IN ARTICLE, COURTESY CARBIDE AND CARBON CHEMICALS CORP.



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1—Standard plastics extruders may be used to produce rods and tubes. 2—Calendered sheeting from polyethylene resins can be made with a relatively smooth surface

POLYETHYLENE

by C. S. MYERS†

POLYETHYLENE resins are a new group of thermoplastic materials. Production of these resins in quantity in this country since early in 1943 is an extension of a successful pilot plant development which began operation in July 1942, following several years of experimental production. The major portion of the production is still being used exclusively for the insulation of high-frequency wire and cable.

The polyethylene resins are semi-rigid, translucent plastics which possess many unusual properties—among them, excellent electrical insulation characteristics. So superior are the low-loss electrical properties of polyethylene resins that these plastics have materially improved the construction of ultra high-frequency wire and cable. However, the material is available in production quantities only by specific authorization of the WPB under Conservation Order M-348.

Polyethylene resins are produced under strictly controlled conditions. By changing the conditions of manufacture, the properties of the resin can be varied to satisfy the needs of particular applications. At the present time only one grade of resin is being produced regularly. Among these variable properties are tensile strength, elongation at break tear resistance and brittleness temperature. The properties of the resin indicate that the use of these materials in future years will be extremely widespread. The art of compounding and using these resins has not as yet been developed fully. It is expected that the properties will be even further improved as more exact processing information is obtained.

† Plastics Division, Carbide and Carbon Chemicals Corp.
* Reg. U. S. Pat. Office

General characteristics and forms

Polyethylene resins are straight-chain polymers of ethylene. They are produced by the direct polymerization of liquid ethylene at high temperatures and high pressures. It is possible to produce the resins in a wide range of molecular weights, each essentially normal, or linear, in molecular structure. The characteristic structure is as follows:

$$\left(\begin{array}{c} \quad\;\; H \;\; H \;\; H \;\; H \\ \ldots\!-\!C\!-\!C\!-\!C\!-\!C\!-\!\ldots \\ \quad\;\; H \;\; H \;\; H \;\; H \end{array}\right)_n$$

Polyethylene resins as produced (Fig. 6) are thermoplastic materials—translucent white in color—which are in-

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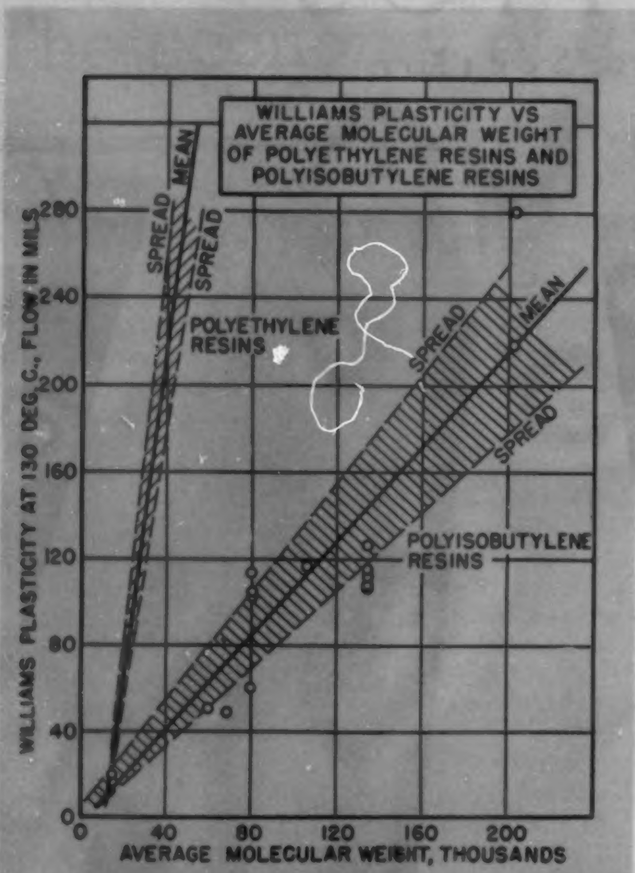

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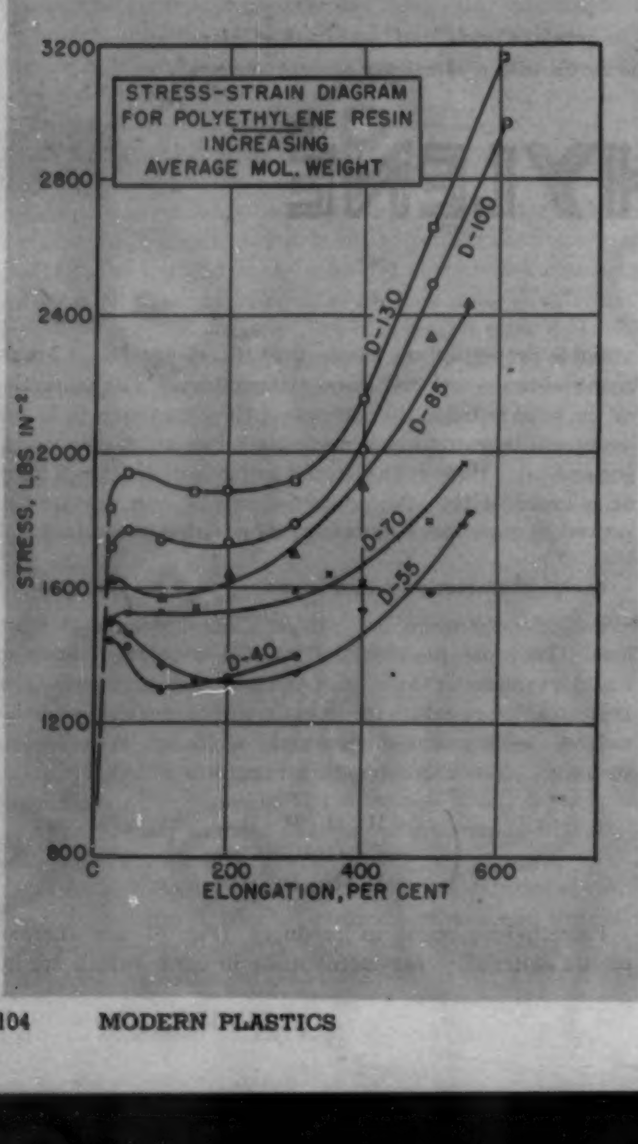

herently flexible. The flexibility is essentially independent of the average molecular weight of the resins and is approximately equivalent to the flexibility at room temperature of Vinylite resin VYNW plasticized with 20 percent Flexol plasticizer DOP. The resins are crystalline in structure. Because of this fact, the tensile strength of the fabricated members may be increased by orientation and cold working. Transparency is also increased by this processing. Dyes and pigments may be added to the resin to produce a wide range of colors of exceptional brilliance.

Polyethylene resins soften sharply at a temperature of approximately 108 to 112° C. While resins of low average molecular weight (10,000 to 14,000) change from a solid to a soft plastic mass in this temperature interval, resins of higher

TABLE I.—PROPERTIES OF STANDARD DYNH POLYETHYLENE RESIN (ELECTRICAL GRADE)

Properties	*Grade D-55 (DYNH)*	*Test method*
Molecular weight (average)	18–20,000	
Specific heat (18 to 40° C.)	0.53	
Heat of combustion: cal./gm.	11,100 ± 15	
Softening temperature, ° C.	108–112	
Moisture diffusion constant		
Mg./hr./cm.^{2}/mil at 30° C.	0.028	Note[a]
Water absorption		
Percent wt. gain, 24 hr. at 25° C.	0.01	ASTM D570–42
Thermal conductivity, cal./cm./sec., ° C.		
Range 0 to 15° C.	0.81×10^{-3}	
25 to 40° C.	0.62×10^{-3}	
Thermal expansion characteristics		
Cubical coefficient, per °C. × 10^6		Note[b]
−35° C.	300	
−20° C.	410	
0° C.	...	
10° C.	550	
20° C.	710	
25° C.	745	
40° C.	870	
60° C.	1,010	
80° C.	1,210	
100° C.	1,400	
110° C.	1,530	
115° C.	750	
115 to 150° C.	750	
150° C.	750	
Thermal diffusivity, cm.^{2}/sec.		
0–15° C.	1.66×10^{-3}	
15–25° C.	Value changing	
25–40° C.	1.37×10^{-3}	
Volatility, percent wt. loss		
72 hr. at 82° C. in air	0.0	
Power factor at 25° C.		
1 Mc.	0.0003	
50 Mc.	0.0003	
Dielectric constant at 25° C.		
1 Mc.	2.3	
50-Mc.	2.29	
Direct current resistivity at 25° C., Megohms-cm.	$>10^9$	
Surface resistivity, ohms	2×10^{14}	
Dielectric strength, volts per mil		ASTM D149–40T
20° C. (0.075 in. thick)	1000–1100	
80° C. (0.075 in. thick)	630	

[a] Vapor-pressure differential, 31.7 m. of mercury.
[b] Clash, R. F., and Rynkiewicz, L. M., "Thermal Expansion Properties of Some Plastic Materials," Ind. Eng. Chem. 36, 279–82 (March 1944).

average molecular weight begin to soften in the same temperature interval but are quite viscose above the softening temperature range. Consequently, the viscosity of the softened polymers above the softening temperature range of 108 to 112° C. is dependent upon average molecular weight.

It has been determined that the flow height of the resin, as determined by the Williams parallel-plate plastometer, is directly proportional to the average molecular weight of the polyethylene resins. This relationship is shown in Fig. 3. For this reason, the resins are defined by flow height as determined in the standard manner.[1] As an example, the grade of polyethylene resin now being made in quantity, DYNH, is designated as "D-55" to indicate that the Williams flow height of this resin is an average of 55 mils at 130° C.

Physical and electrical properties

In Table III, the properties of various grades of polyethylene resin are summarized. The stress-strain diagram of various grades of polyethylene resins are shown in Fig. 4. These diagrams, together with the data of Table III, indicate the desirability of the high molecular weight grades of resin for many applications. Additional physical and electrical property data for currently standard polyethylene resin are shown in Table I. These tables and charts demonstrate the extremely low moisture-diffusion constant of the polyethylene resins, their excellent electrical characteristics and their excellent low-temperature properties (Fig. 5).

Methods of fabrication

In general, polyethylene resins are fabricated in almost exactly the same manner and on the same machinery as are

[1] Industrial and Engineering Chemistry *16*, 362 (1924).

3—This graph shows the relationship between the flow height of the resin, as determined by a Williams parallel-plate plastometer, and the average molecular weight of the resin. 4—The stress-strain diagram of the various grades of polyethylene resins. 5—This graph indicates the temperature-stiffness comparison of various polyethylene resins. 6—Polyethylene resins are tough, horny, translucent materials. 7—Film in thicknesses of 3 mils is eminently satisfactory for wrapping foils. 8—The electrical properties of polyethylene resins make them highly suitable for use as electrical wire insulation and jackets

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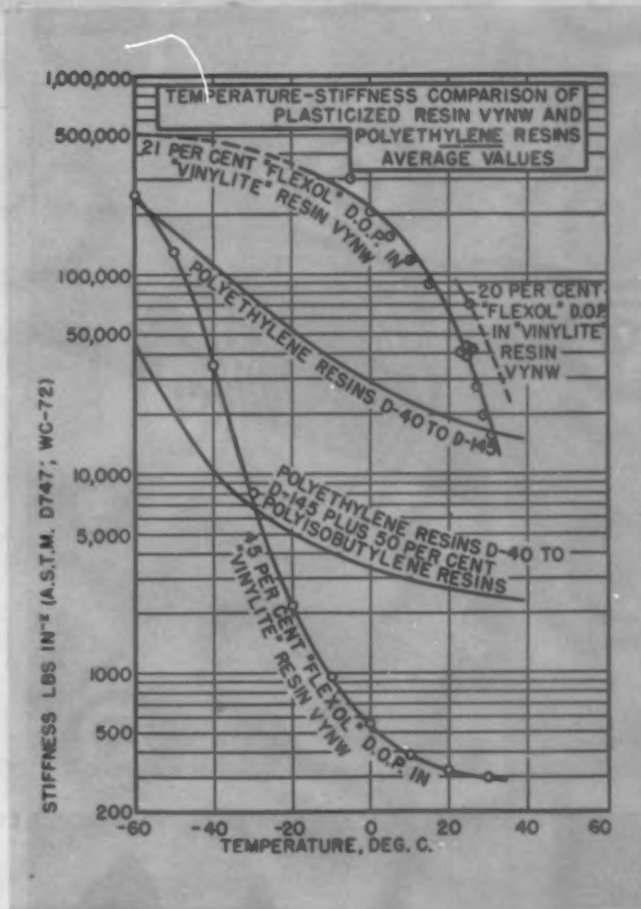

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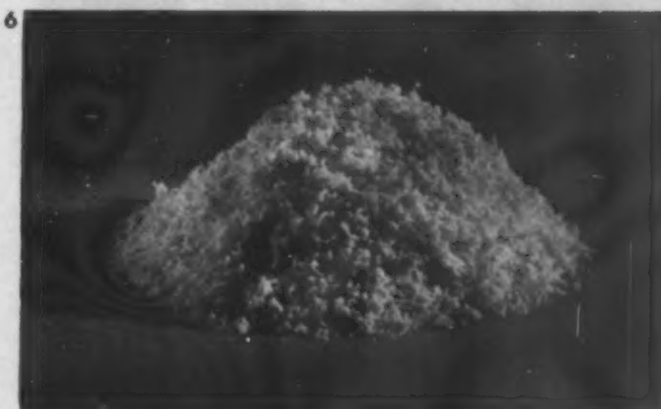

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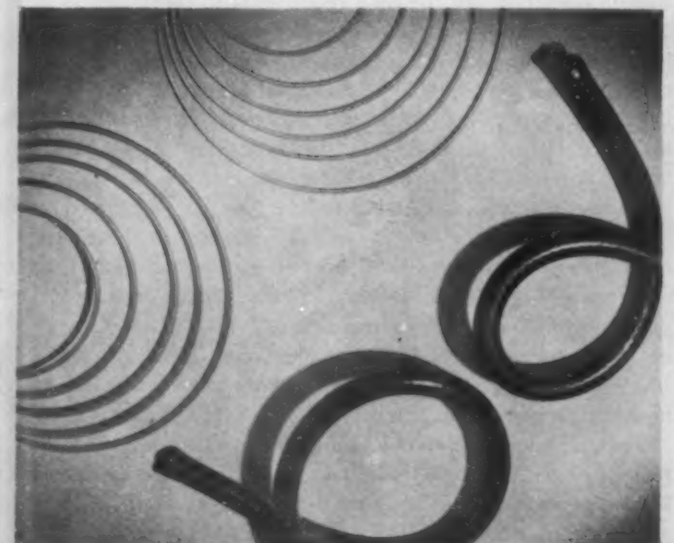

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9—Containers that are form-stable in boiling water may be fabricated by blow-molding. 10—Conventional presses are used to emboss the sheeting. 11—Cloth coatings in a range of brilliant colors are practical applications of polyethylene resins. 12—Translucent press polishing sheeting can be produced in a variety of thicknesses. 13—This graph indicates the temperature sensitivity of polyethylene solubility. 14—This diagram shows solubility characteristics of one polyethylene over a wide temperature range. 15—Monofilaments can be produced in a wide range of colors. 16—Standard injection molding methods are applicable to polyethylene resins

the vinyl chloride-acetate resins. The principal differences between the two materials is the higher softening point of polyethylene and the much higher coefficient of cubical expansion of polyethylene. It is believed that fabricators familiar with vinyl chloride-acetate resins will have little difficulty in adjusting their processes to accommodate the polyethylene resins.

Extrusion—Conventional plastics and rubber equipment is satisfactory for the extrusion of polyethylene resins. The operating conditions applying to the new materials are essentially the same as those used with other thermoplastic materials. The specific factors influencing success of the extrusion operation are the high coefficients of thermal expansion of the compounds. Modified extrusion die design allows high extrusion rates. Thick extruded sections require special cooling technique to avoid voids in the center of the section.

Polyethylene resins can be extruded to produce the following types of products: 1) Wire insulation and jackets (Fig. 8); 2) Tubing, rod, tape and monofilaments (Fig. 1), and 3) Coatings on rope, twines, etc.

Calendering—After suitable compounding modification, polyethylene resin can be calendered under conditions that are normally applicable to vinyl chloride-acetate resin compounds (compound temperature 105 to 150° C.). Relatively smooth sheeting (Fig. 2) can be calendered in thicknesses of 100 mils and calendered films in thicknesses of 3 mils result in an attractive product suitable for wrapping foils (Fig. 7).

The following calendered products can be produced from polyethylene resins: 1) Sheeting and films, unsupported; 2) paper coating and impregnation; and 3) cloth coating and impregnation (Fig. 11).

TABLE II.—THERMAL EXPANSION CHARACTERISTICS OF POLYETHYLENE RESINS

Temperature (t), ° C.	Linear expansion coefficient × 10^5	Cubical expansion coefficient × 10^6	Specific volume ratio $\frac{V_t}{V_{25°C.}}$
−35	10	300	0.969
−20	13.7	410	0.975
0	18.3	550	0.986
20	23.7	710	0.997
25	24.8	745	1.000
40	29	870	1.012
60	33.7	1010	1.031
80	40.3	1210	1.055
100	46.6	1400	1.094
110	51	1530	1.130
115	25	750	1.142
115 to 150	25	750	...
150	25	750	1.168

Molding—Standard compression and injection molding operations used with thermoplastic materials are applicable to polyethylene resins. However, certain inherent properties of the resin influence the molding characteristics to a significant degree. The high coefficient of cubical expansion and contraction of polyethylene resins, shown in Table II, necessitates careful attention to mold design if the molded parts are to be produced to close dimensional tolerances. For example, if the temperature of a massive piece of polyethylene is raised from 25 to 115° C., the piece will increase 14 percent in volume. Cooling a molded section from the elevated temperature results in a corresponding shrinkage. The result of such dimensional change is a product which no longer duplicates the dimensions of the mold cavity. Also, shrinkage voids may be formed due to the high degree of contraction unless special cooling and molding techniques are employed.

Planishing and embossing—Calendered sheeting can be planished (Fig. 12) or embossed (Fig. 10) in the conventional platen press. Because of the characteristic sharp softening point of the polyethylene resin D-55, some care is required in the application of the hydraulic loading and in the heating of the press in order to avoid extrusion of the compound from between the plates. The higher molecular weight grades of polyethylene are more amenable to the planishing operations and are more satisfactory for planished sheet applications because of improved physical characteristics.

Blow molding, swaging and drawing—Polyethylene resin sheeting may be fabricated by con- (*Continued on page 174*)

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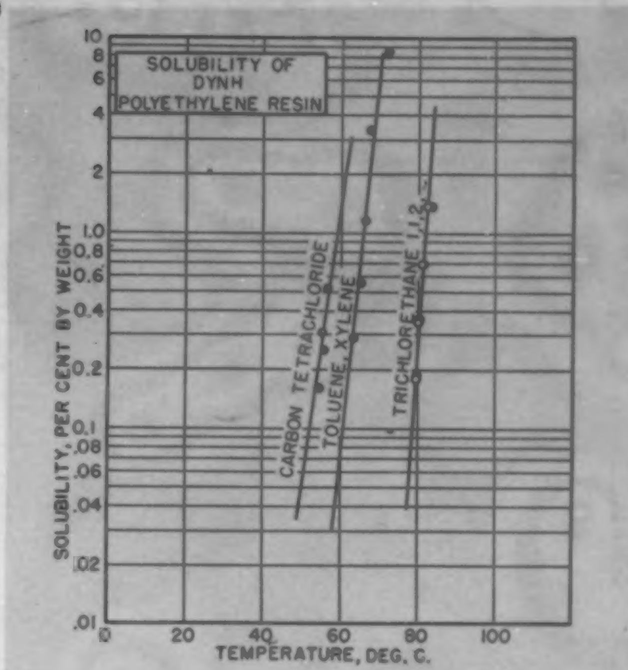

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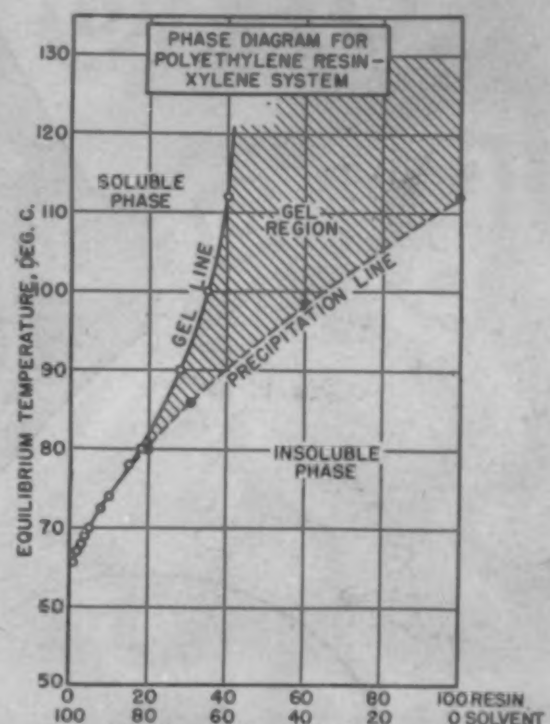

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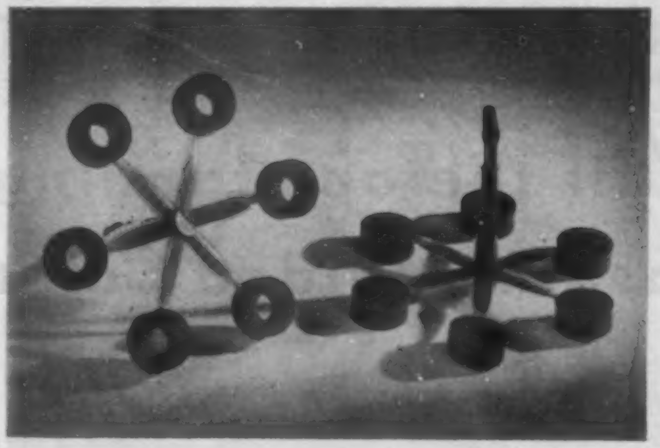

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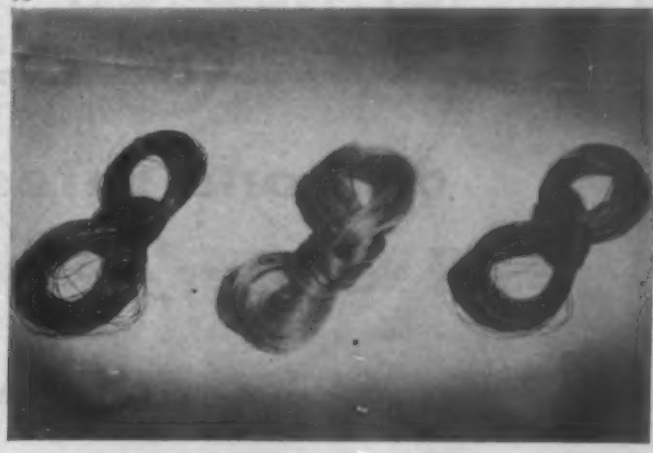

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Infrared for drying and preheating

by WILLIAM J. MISKELLA*

THE use of infrared lamps to dry or preheat plastic material before molding is not a recent development. However, any real expansion in the use of this type of equipment was somewhat limited by the fact that until 1944 most of the infrared driers were home-made and were utilized with a greatly varying degree of success and efficiency. Until a tested standard commercial infrared drier was made available at a reasonable price, it was impossible to convince molders how inexpensive and efficient drying and preheating with infrared heat can be.

Drying of plastics

A wide variance in apparent moisture content of various drums of plastic material is frequently noted even when the barrels are stored on raised blocks under constant temperature conditions in a dry room. Since there is as yet no easy way for molders to make a quick chemical test to determine the amount of moisture in a given batch of material, the only solution is to mold some of the material and see if moisture appears on the part.

Many plants seem to get along with a minimum of drying; others religiously dry every pound of material. Today in the plastics industry there seems to be no rule one can adduce about drying—about when to dry, the costs, the advantages—other than the rule of thumb whereby the surface of the molded part is observed and the piece subsequently cut open in search of flaws that might be attributed to the presence of moisture. If the familiar mica marks, stars, checks or rough spots are present, drying is usually indicated since these marks, generally most noticeable when radiating from a gate or weld mark, often indicate a structural weakness. A moisture mark is also likely to be an ultimate point of fracture, scaling or peeling. However, in addition to this visual study of the molded piece, chemical tests can and should be made wherever possible.

Moisture marks are particularly unsightly on smooth surfaces and are the cause of many rejections. In the lower pressures used in extrusion, the least trace of moisture (often as little as a fraction of a percent) shows up plainly as a rough surface or swelling, lacking finish, dimension and strength. Therefore, drying of the material is often more important to the extruder than to the injection molder.

Because of the degree of uncertainty as to the particular cases in which drying of the plastic material is advisable, it was not until the latter part of 1943 that a commercial infrared drier and preheater was designed which incorporated many important features often overlooked in the home-made units. Figure 1 shows this new drier with one side removed so that the material can be seen as it passes through the unit. It was found necessary when developing this equipment to supplement the principle of infrared drying so that the material passes over a hot metal tray which draws its heat from the drying lamps. A vibrator, which is mounted under this plate by means of a specially designed framework, causes the plastic granules to dance across the tray and prevents the particles from sticking, whether it be from overheating, clogging or uneven particle size. If the tray is too thin, the additional heat which should be stored in the metal sheet is quickly dissipated. This extra heat is also lost if a

* Chief engineer, Infra-Red Engineers and Designers.

ALL PHOTOS, COURTESY INFRA-RED ENGINEERS AND DESIGNERS

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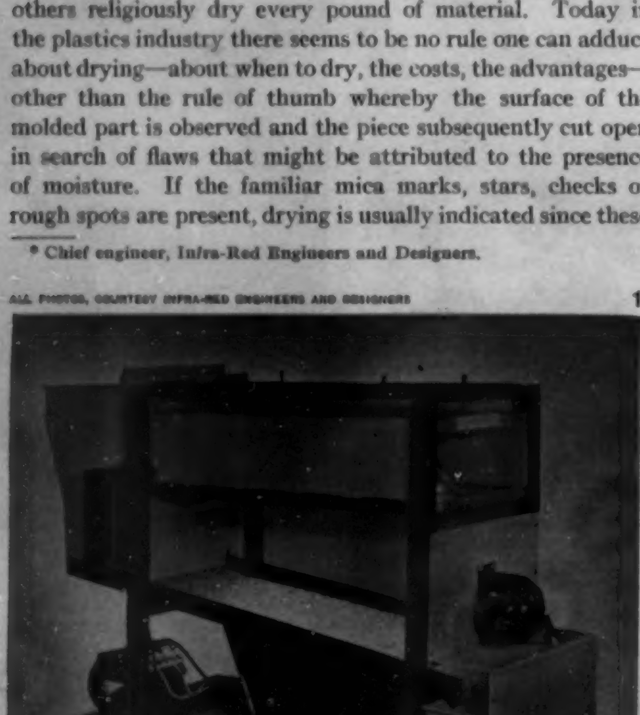

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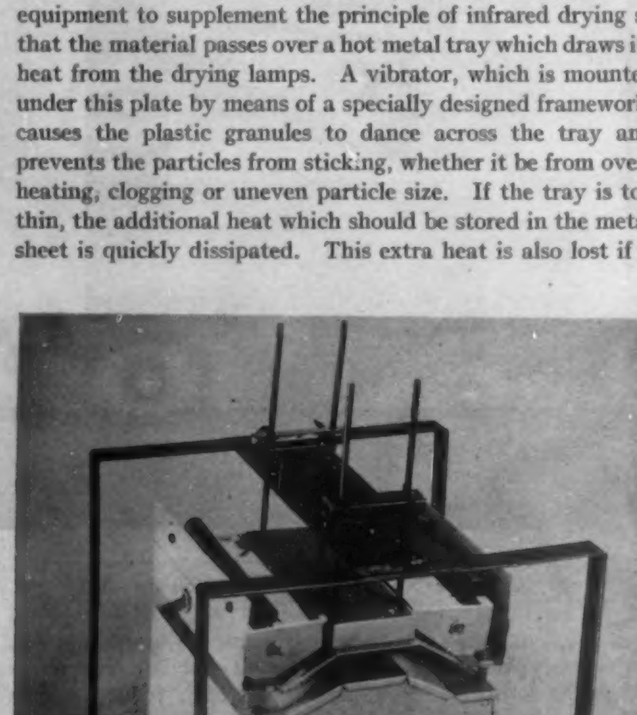

conveyor belt is used. Consequently, a drier that employs a thin tray or conveyor belt is inefficient and requires extra batteries of lamps—materially increasing operating costs as compared with those prevailing when a vibrator and heavy tray combination is employed.

The heavy tray, reinforced by the vibrator support, must be strong enough to resist warping under the high heats that are sometimes employed for materials such as the new heat-treated acrylics that take temperatures up to 440–450° F. A variable control on the vibrator makes possible an increase in vibrator speed for materials requiring only brief drying and enables the drier to be emptied quickly at a job change. A readily adjustable gate under the feed hopper, acting in conjunction with the vibrator, controls the actual rate of material flow under the lamps.

To remove volatile elements completely from the drier, especially moisture, a blower was found to be necessary. This moving air stream also prevents plastic dust from rising and fusing on the lamps, from which it can be removed only with difficulty. The stream of air developed by the blower goes counter to the flow of the material and is forced to pass out of the unit through a broad flue.

As a protection against the action of the vibrator, the infrared lamps are suspended from a support mounted inside the main structural frame. A highly reflective cover plate, thickly insulated so as to retain the rising heat, is also suspended from this lamp support. The bulbs are closely fitted to the openings in the reflector in order to effect a maximum seal against the passage of rising heat between the bulb and the reflector and to assure maximum reflecting surface.

To control the heat, a series of switches is arranged so that the lamps may be switched on and off in groups as required. In addition, an a.c. regulator gives inexpensive control over the volume of heat put out by the infrared lamps. This latter arrangement makes possible a more effective control over the drying process and insures a material increase in the range of the drier (varying from 10 to 125 lb. per hr.) at temperatures from 100 to 300° F., or higher.

The entire drier unit must be fully enclosed to prevent any dust or other contamination from entering the drying chamber. Furthermore, the feed hopper should be kept covered whenever possible. Especially in drying and handling clear materials, great care must be exercised to prevent contamination. The almost magnetic affinity of clear material for any foreign matter is often a source of trouble in the molding plant. In some cases where very fine dust or moisture is encountered, the use of filtered and conditioned air throughout the plant is indicated.

Most molders are well aware that some plastic materials (especially the acetates), upon cool- (*Please turn to page 182*)

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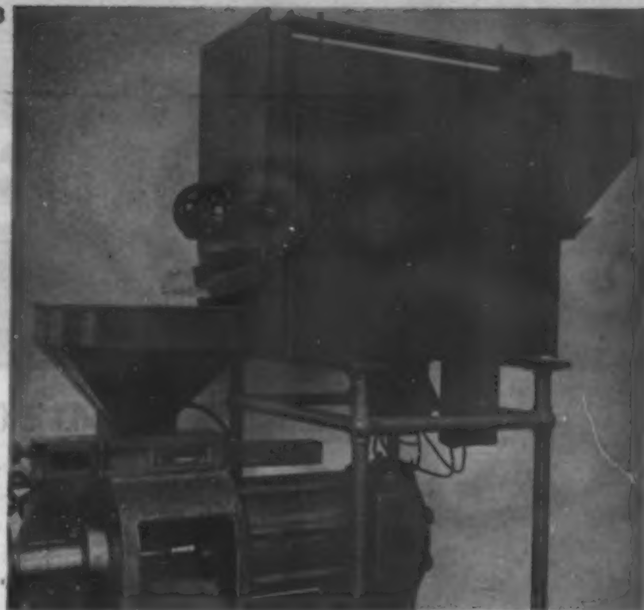

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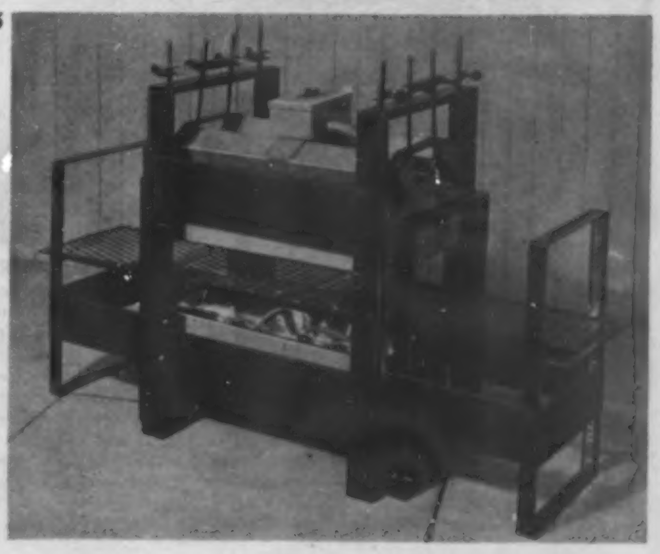

1—A standard commercial infrared tray-vibrator type ventilated drier mounted on a semi-portable truck. 2—This commercial infrared hopper drier is designed for mounting on the hopper of an injection machine. A mirror has been placed below this unit to show the position of the dual lamps. 3—When a drier is used for preheating, it is best to mount the unit so that it will discharge the material directly into the hopper. In this case the integral supports rest directly on the floor. 4—A small sheet plastic softener with adjustable lamp height and heat-reflecting tray. 5—In this standard commercial infrared preform heater the two lamp clusters are located above and below the expanding metal trays

Life on the *Plastics*

PRECISION SNAP ACTION SWITCHES UTILIZE BEETLE

(*Above*) **BEETLE'S VARIETY OF COLOR** has been utilized for the basic Micro Switch covers to provide a means of instantly identifying contact arrangements and the various types of switches.

• On American bombers, the bomb bay signal light, the bomb handling mechanism, the bomb release mechanism—and dozens of other vital functions from nose turret to trim tabs—are controlled by thumb-size, featherweight switches of amazing precision, product of Micro Switch Corporation.

Micro Switch housings and accessories are built to resist vibration, to function reliably when subjected to high altitudes, sub-zero temperatures, salt air, and the violent maneuvers of aerial combat. Precision molded plastic housings using Cyanamid's BEETLE* are used because of the dielectric properties, dimensional stability, light weight, color, and high speed production possible on this plastic material.

*Reg. U. S. Pat. Off.

(*Above*) **BECAUSE OF ITS ADVANTAGES** of dielectric strength, dimensional stability, color, and light weight, BEETLE is molded into covers for the basic Micro Switch on this Stokes Automatic Molding Press.

(*Below*) **A THIN METAL LEAF** is attached to the BEETLE cover to provide a leaf type actuator. The screws are run through the leaf spring and into the plastic Micro Switch cover. All materials used in the switches are subjected to various chemical, temperature, and altitude tests to be sure they will function properly under all service conditions.

(*Above*) **PLASTIC-HOUSED MICRO SWITCHES** are inserted, in some instances, into larger die cast metal housings, while many are used without any additional protective housing.

(*Right*) **BEETLE COVERS** are applied after the switch mechanism has been assembled in the housing, and are permanently sealed in position. BEETLE's dimensional stability is of great importance since there must be extremely accurate fitting of all parts. All materials and mechanism in these precision switches must be able to retain their essential characteristics under long continuous service since the switches may be operated literally millions of times.

High frequency solves molding problem

by LYMAN L. DAWSON*

HIGH-frequency dielectric heating of preforms is opening up an entirely new field in the transfer molding of thermosetting resin compounds. The ability of the plastics industry to handle larger and more complicated parts is largely dependent upon its ability to heat greater masses of molding materials rapidly and uniformly. Today, the most efficient means of achieving this end is through the use of high-frequency heating. An example of so-called impossible jobs which are now being produced on a round-the-clock basis through the use of dielectric heating is an aircraft engine ignition distributor head molded from asbestos-filled melamine compound.

Because of the low thermal conductivity properties of the compound, the size of the part, the close nesting of a large number of pins and the complex arrangement of 17 metal inserts, the molding of the distributor heads for a 12-cylinder aircraft engine presented a particularly stubborn problem. In order to secure proper flow from the transfer chamber into every section of the mold, the $2^1/_4$ lb. of preformed plastic was preheated to 250° F. before it was placed in the loading well. Only by a rapid, uniform heat could such a mass be heated to the center without overheating the surface at the same time. If the core were underheated, the material could not be made to flow into the cavity without the use of such great pressure that pins would be broken or bent and inserts sheared or moved out of position. If the surface of the preforms were overheated in an attempt to soften the core, the compound would begin to set, causing equally disastrous results.

Following 9 months of experimentation in preheating with electric ovens and infrared, work on this job was stopped for several weeks in the plant under discussion because of the company's inability to reduce the number of rejects to the point where production was practical. In March 1944 a new high-frequency dielectric heating unit with an enclosed preheater cabinet was installed, and within a week the molding of the distributor heads was proceeding on a production basis. By May 1 slight mold changes and other adjustments had been made, and the job was proceeding smoothly with the oscillator uniformly heating a steady stream of preforms that keep the two semi-automatic molding presses operating continuously through 3 daily shifts, 6 days a week. One operator easily handles both presses.

Figure 1 shows the compact arrangement of the two presses with the high-frequency unit placed between them. The two preforms that are required to mold one distributor head have just been placed in the heating drawer at the right of the generating unit, and the operator is starting the cycle by tuning the machine. The preheating is accomplished by placing the preforms in a removable cast-aluminum drawer which acts as the lower electrode and is readily pushed back into the preheater cabinet mounted on the side of the generating unit. This generator produces a high-frequency power which passes directly through preforms placed between the two electrodes. The dielectric loss factor of the material and the passage of the electrical power produce heat within the preforms themselves. The top electrode, which is also made of cast aluminum, is adjustable—its position being indicated on the outside of the cabinet by a calibrated dial. It is generally positioned to provide an air gap above the preforms so that the drawer can be moved with ease.

During the heating of the preforms, the operator sets upon an assembly board the 17 metal inserts that are molded into each distributor head (Fig. 2). The operator then transfers these inserts to keyed positions in the lower mold force of one of his presses (Fig. 3). For this particular molding job, two preforms with a total weight of $2^1/_4$ lb. are placed in the drawer. After 4 min. between the electrodes, the mineral-filled mel-

* Vice-president in charge of Thermex Div., Girdler Corp.

ALL PHOTOS, COURTESY THE GIRDLER CORP.

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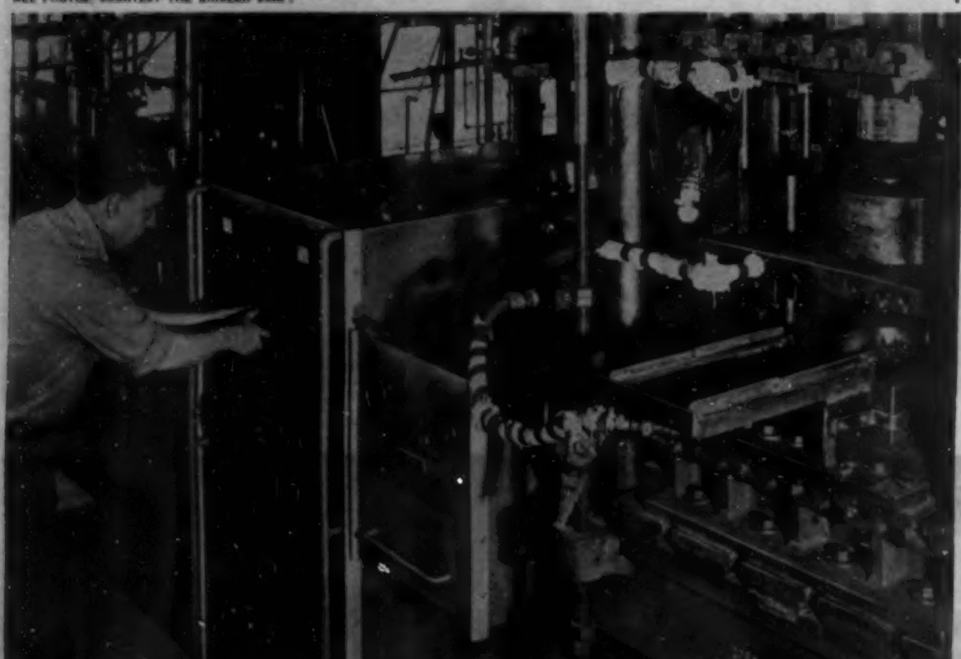

1—A high-frequency unit sits compactly between the two semi-automatic presses which it services. 2—The operator is shown setting up on an assembly board the 17 metal inserts molded into each distributor head. 3—Here the inserts are being transferred to keyed position in the lower mold force of a press. 4—On completion of the 4-min. heating cycle, the preforms are tested for plasticity. 5—In the transfer of the preforms from preheater drawer to loading well, the time element must be held to a minimum to avoid setting up of the material prior to its molding

amine compound is heated to 250°F. At this stage the material reaches a degree of plasticity where the operator can push a finger and a thumb into the preform (Fig. 4) much as he might with a ball of putty.

The opening of the preheater drawer automatically opens the circuit and eliminates all danger to the operator. Any resumption of the heating involves the use of the starter button control on the instrument panel. Because there is such a slight difference between the softening point, flow point and setting-up point of the melamine, the period between the time the operator removes the preforms from the drawer and the time he places them in the loading well (Fig. 5) must be held to a minimum.

In this steam-heated well, the heating process is continued throughout the 3-min. press-closing time during which the mold plunger compresses the melamine and transfers it to the mold cavity. With a pressure of 70 tons exerted on the 12-in. ram, the compound, which flows freely between 290 and 300°F., is forced through the two gates into the heated cavity. Here it is held under pressure for another 5 min. before an indicating light signals the operator that the thermosetting reaction is completed and that the finished head is ready for removal from the mold (Fig. 6). The gates that are used in molding these distributor heads are believed to be the largest openings in use in transfer molding today.

A slight change is being made in the mold to eliminate the need for lifting the 43-lb. cage from the press after each molding cycle, and moving it to the bench. Up to the present this manual operation has been necessary to permit the withdrawal of the section containing the pins. These pins form the holes through which the wiring enters the finished head.

Asbestos-filled melamine is a white thermosetting compound that has high dielectric properties and cures into a light grayish-brown product possessing excellent physical qualities. It was selected for this head because of its high dielectric properties, its ability to withstand the heat of a high-speed engine and the low temperature of the substratosphere. It must withstand 25,000 volts for 3 min. and have a flexural strength of 10,000 pounds. Its specific gravity is 1.78. In the moisture-resistance test it must (*Please turn to page 178*)

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PHOTOS, COURTESY J. M. NASH CO.

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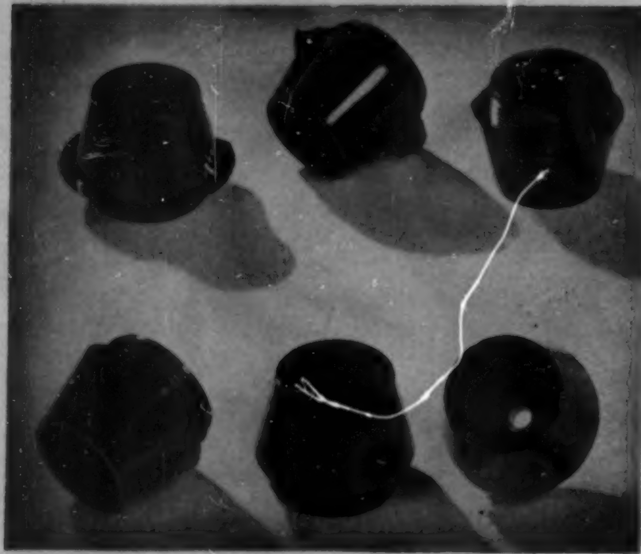

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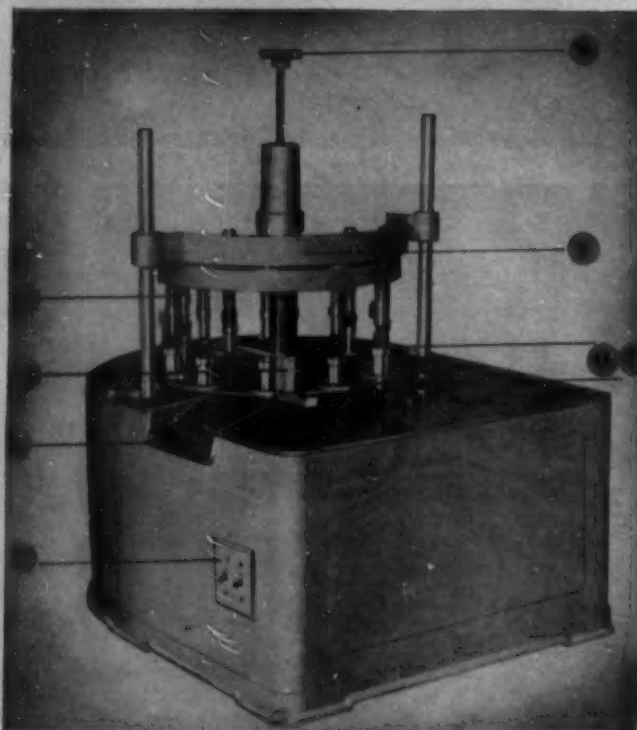

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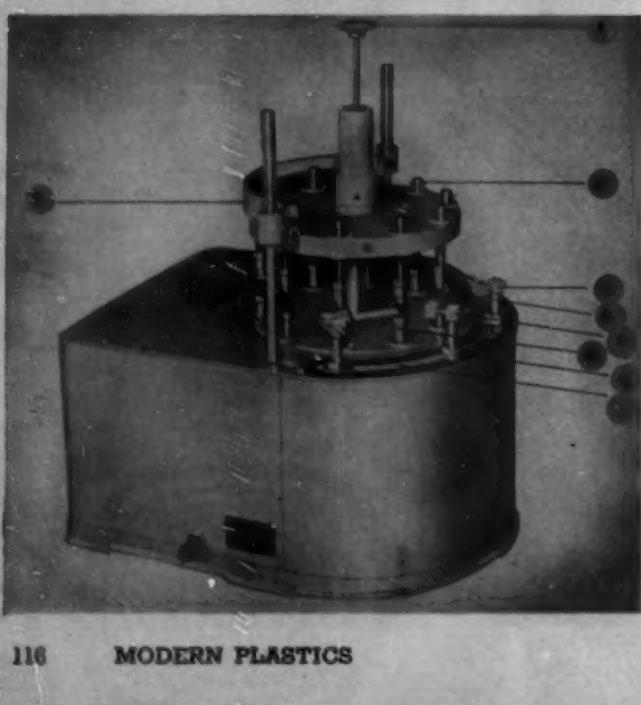

New flash lathe

EVEN the simplest finishing operation takes considerable time and labor. When, as in the case of the M-52 fuze, the orders for a single part run into the millions or when a large and varied stock of plastic pieces is produced by one company, the time and the labor involved in the removal of flash, in buffing and in like operations can mean the difference between meeting delivery dates and falling behind schedule.

In an effort to reduce the number of man-hours consumed in finishing operations and, at the same time, produce better quality work at a lower cost, the J. M. Nash Co. has engineered an automatic flash lathe (Figs. 2 and 3). Designed for the removal of flash on cylinders, knobs and similar rounded articles, the first production unit is now in operation—speeding delivery of M-52 fuze noses (Fig. 1). Entirely automatic except for the hand work involved in loading the unfinished pieces onto the unit, the lathe has a production rate ranging up to 60 pieces per minute.

Basically, this finishing machine consists of a number of spindles mounted on a turntable. Work placed between pairs of spindles is revolved at a high rate of speed as the spindle-work unit moves around the circumference of the work table, past the various finishing stations. The top spindles (one of which is shown at C in Fig. 3) hold the plastic parts securely during their travel over the working area. Since the centers of these spindles are ball bearing mounted, the spindles can come up to the proper revolutions per minute without slippage.

In order to achieve accurate adjustment on work stations so that flash removal can be confined to the smallest area, spindles are carefully spaced over the wheel circumference. To guard against the possibility of damage, the molded pieces are held in place between the top and bottom spindles by friction disks. As a further protection, the spindles are held motionless while the molded parts are loaded and ejected. The ejection finger (J in Fig. 2) automatically sweeps the molded and finished piece from the bottom center of the spindle into the ejection trough (K) which is placed directly over a suitable container.

Of the 10 spindles on this automatic lathe, the bottom spindles alone are driven—the upper spindles being designed for work location. When all 10 spindles are used, plastic parts up to $4^1/_2$ in. in diameter can be put through the machine. However, only alternate spindles may be employed for work larger than $4^1/_2$ in. but not over $6^1/_2$ inches. Standard height adjustment is limited to 6 in., although machines can be supplied to meet special requirements. A change in the adjustment screw (A) raises or lowers the top wheel and thereby makes possible the insertion of plastic parts of different sizes.

Since the spindle and feed drives are independent, the speed of either or both can be altered by a change of the controls (L) to achieve the combination (*Please turn to page 178*)

1—Finishing operations on plastic parts manufactured in large quantities, such as the M-52 fuze noses shown here, are stepped up and improved by the use of automatic flash removing lathes. 2, 3—Two views of the flash removing lathe showing the various parts involved in the functioning of this machine. Explanatory data on identifying letters is given in the text of the story

Farmer's Friend
Electric fence controllers, with transparent housings of shatterproof Tenite, aid in segregating livestock and protecting gardens from predatory animals. At approximately one-second intervals, an oscillating rotor pendulum, visible through the Tenite housing, delivers a charge to the fence wire. A neon signal light inside the housing indicates whether a proper charge is being placed on the wire.
This Tenite housing will not dent or corrode, and its dirt-resistant surface is permanently lustrous. Tenite has low moisture absorption and good dimensional stability. It is a tough material that withstands hard wear and rough treatment. The many Tenite products used on the farm include garden tool handles, insecticide sprayers, irrigation tubes, lightning arresters, and milking machine parts. For further information about Tenite and its many uses, write TENNESSEE EASTMAN CORPORATION (Subsidiary of Eastman Kodak Company), KINGSPORT, TENNESSEE.
TENITE REPRESENTATIVES
New York, 10 East 40th Street. Buffalo, 1508 Rand Building. Chicago, 1564 Builders' Building. Dayton, Ohio, 305 Third National Building. Detroit, 904-5 Stephenson Building. Leominster, Massachusetts, 39 Main Street. Washington, D. C., 1125 Earle Building... Pacific Coast: Wilson & Geo. Meyer & Company—San Francisco, 15th Floor, 333 Montgomery Street, Los Angeles, 402 Architects Building, Seattle, 1020 4th Ave., So.
Electro-Line fence controller housings are molded by Eclipse Moulded Products Company.
Tenite an Eastman Plastic

The behavior of plastic materials under repeated stress*

by B. J. LAZAN and A. YORGIADIS†

THE trend in present-day engineering toward higher speeds has greatly increased the importance of vibrations as a factor in the design and behavior of machine and structural elements. In view of this ever-growing prominence of dynamic forces, an adequate engineering analysis of a design or a significant comparison of materials is no longer possible if only the usual static properties are known. Complete information on the behavior of materials under vibrations is now an acknowledged necessity.

The inadequacy of present-day knowledge of the dynamic properties of materials is revealed by studies of service failures. For example, over 95 percent of the automobile failures covered by one study (37)[1] were caused by dynamic forces. Consequently, more critical thought must be given to methods of testing which isolate and reveal the significant dynamic properties of materials.

The rapid development of structural plastics has not been accompanied by a corresponding development in dynamic testing techniques. Usually when studying the behavior of plastics, it has been necessary to employ machines developed primarily for testing metals, and the justification and limitations of this expedient are not always fully realized by the test engineer. Therefore, this paper will emphasize many important differences between metals and plastics. The significance of these differences as related to dynamic testing will also be discussed.

Definitions

Since the nomenclature used in the field of dynamic testing is not wholly consistent, the following definitions are presented for the sake of clarity:

Static forces (stresses) remain essentially constant or change slowly without exhibiting any repetitive characteristics.

Dynamic forces (stresses) include all those not considered static. The most common types of dynamic forces follow:

1. *Alternating forces* fluctuate between two limits, usually in a sinusoidal manner. Vibrations generally induce alternating forces. In specifying an alternating force both the mean force F_m (Fig. 1) and alternating component F_a must be stated.
2. *Reversed forces* are alternating forces in which the two limits are equal in magnitude but opposite in sign. That is, $F_m = 0$ for reversed forces.
3. *Impact forces* are generally produced when the kinetic energy of colliding bodies is absorbed by deflections in the material. Impact forces usually possess a high rate of change relative to time.

Dynamic tests reveal the mechanical behavior of materials under dynamic forces. This behavior is quantitatively expressed by dynamic mechanical properties.

* Abridged from a paper presented at the "Symposium on Plastics" held in Philadelphia, Pa., on Feb. 22–23, 1944, and published here through the courtesy of the American Society for Testing Materials.

† Chief engineer and research engineer, respectively, Sonntag Scientific Corp.

[1] Numbers refer to bibliography at end of paper.

1—*This drawing defines the types of dynamic forces.*

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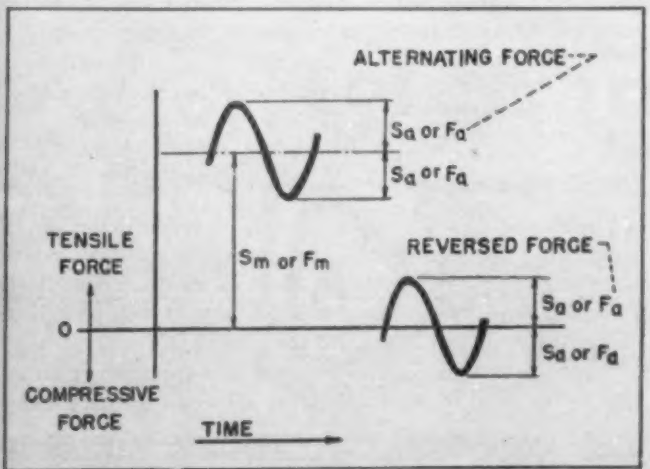

2—*Equilibrium temperature of plastics under cyclic stress*

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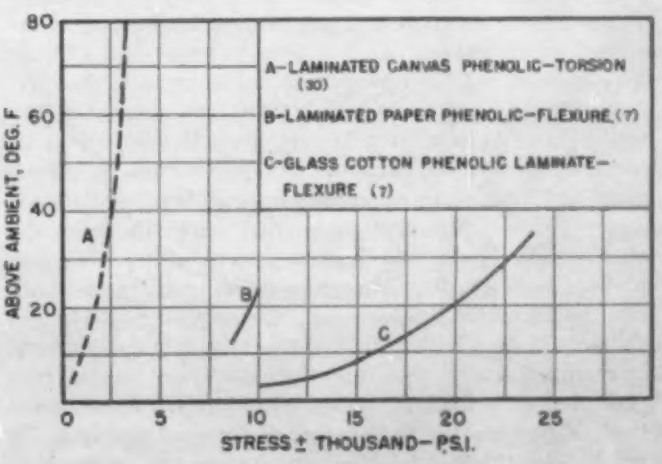
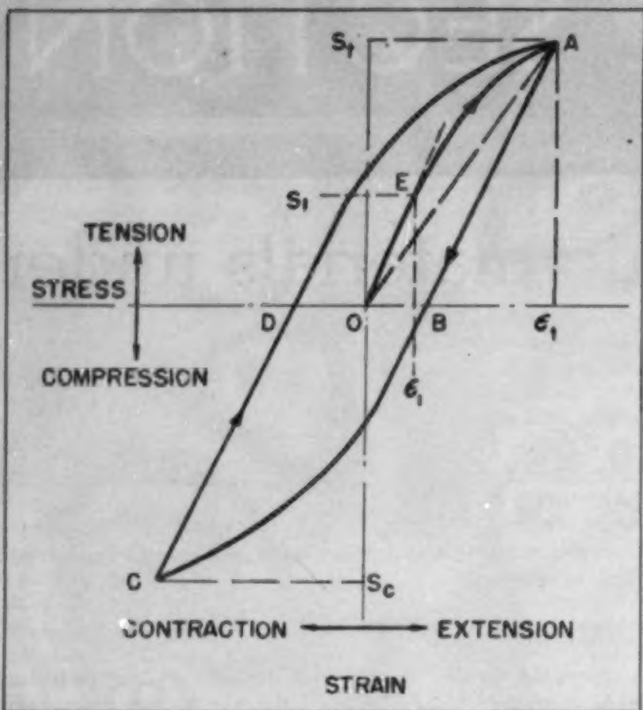




3—Typical stress-strain curve of a plastic under reversed stress. This graph shows the hysteresis loop

Inelastic behavior of materials

The inelastic behavior of a material, as revealed by its nonlinear stress-strain curve, provides a basic explanation of many dynamic properties of materials. Therefore it is expedient, as an introductory explanation, to examine the stress-strain behavior of materials under alternating stress.

The stress-strain curve for a typical plastic subjected to vibratory stress is shown in Fig. 3. For simplicity it is assumed that the specimen vibrates between equal limits of tension and compression under completely reversed stress. Because of hysteresis effects in the material (often associated with internal friction, localized yielding, creep effects, etc.) the unloading branch AB of the stress cycle falls to the right of the initial loading branch OEA (curves OEA and AB coincide only for perfectly elastic materials). The permanent set OB, which remains after stress cycle OAB, is a measure of the inelasticity in the material up to stress S_t.

The damping capacity of a material depends on the net energy absorbed by the material during a stress cycle and is proportional to the area within the hysteresis loop $ABCDA$. This area increases rapidly as the amplitude, S_t or S_c, of the stress cycle increases. To date, experimental data indicate that no material displays zero damping capacity however small the cyclic stress may be. Thus, no material is perfectly elastic even at very low stresses. It follows that no material obeys Hooke's Law of exact proportionality between stress and strain under alternating force. Many low-damping metals require instruments of unusual sensitivity before deviations from Hooke's Law can be detected statically. Most plastics, however, display large deviation from Hooke's Law, and the associated hysteresis loop may easily be detected.

Since the area within the hysteresis loop, or the damping, represents an energy loss, it is a measure of the internal heat generated by a material under cyclic stress. This internal heating increases the temperature of the specimen up to the point where the heat loss from the specimen to the environment equals the energy represented by its damping capacity. Plastics possess high damping capacity and low thermal conductivity—a combination that may result in very high specimen temperature. Figure 2 shows temperature increases of three plastics under sustained cyclic stress. The significance of these temperature increases will be discussed in later sections of this paper.

The inelastic behavior of materials as evidenced by internal heating does not always indicate impending failure. For example, one fatigue test on record (34) was continued over 3 years, during which period there was sufficient inelastic behavior, or damping, in the specimen to maintain its temperature above 270° F. Nevertheless, after a billion stress reversals "the specimen was still unbroken and showed no signs of failure." Hysteresis damping should not, therefore, be associated with weakness in a material. In fact, it may be a very desirable property in service, a fact which will be discussed in a later section of this article.

Basic dynamic properties of materials

The types of dynamic forces imposed on machines and structures in actual service are varied and sometimes quite complex. Consequently, the only absolute and foolproof test of serviceability of a part is actual service. However, it would be a very expensive and time-consuming procedure to rely exclusively on actual service records as a criterion of the suitability of 1) the material, both old and new, and 2) the design and proportion of a part.

Service records must be supplemented by laboratory testing. And when service records are unavailable, laboratory test data must be used as the sole criteria for judgment.[2] In general, the best laboratory test is that which simulates actual service most closely.

The types of laboratory tests used to predict behavior of materials in service may be classified in two groups as follows:

1. *Arbitrary tests* which impose rather special and uncommon test conditions in order to reveal the suitability of a material or design for a special well-defined application. For example, the applicability of plastic sheets as soles for shoes may be partially explored by an arbitrary flexing test (11).
2. *Basic tests* which impose simple and well-defined forces on materials and are designed to reveal properties which can be used for predicting the general behavior under different types of service.

In general, basic tests are more valuable for evaluating new materials and for providing the design engineer with a set of basic data for calculating serviceability. This report is restricted to a discussion of the basic dynamic tests of materials, among which the following are the most important:

1. Damping capacities.
2. Dynamic moduli of elasticity.
3. Fatigue strength.

Damping capacity

The damping capacity of a material is proportional to the area within the stress-strain hysteresis loop and thus represents the energy per cycle of vibration dissipated as heat. Damping capacity so defined has the units of inch-pounds of energy per cycle and is assigned the symbol D.

The resonance amplification factor of a specimen or structure is the ratio of the total stress induced in a part under

[2] Very frequently the uncertainty of the types and magnitudes of forces imposed on the part rather than the unknown behavior of the materials is responsible for unexpected service failure.

resonant vibrations to the magnitude of the alternating force which excites the vibrations. The R. A. factor is a reciprocal function of damping capacity—high damping means low R. A. factor.

High damping capacity in a construction material may be either advantageous or harmful, depending on the application. It is beneficial in the following respects:

1. *Limits near-resonance vibration stresses*—In modern high-speed machinery near-resonance vibrations occur rather frequently. The increased and uncontrolled stress resulting from these near-resonance vibrations is one of the most common causes of premature service failures. The dynamic stress in a part at resonance may be expressed by the following equation:

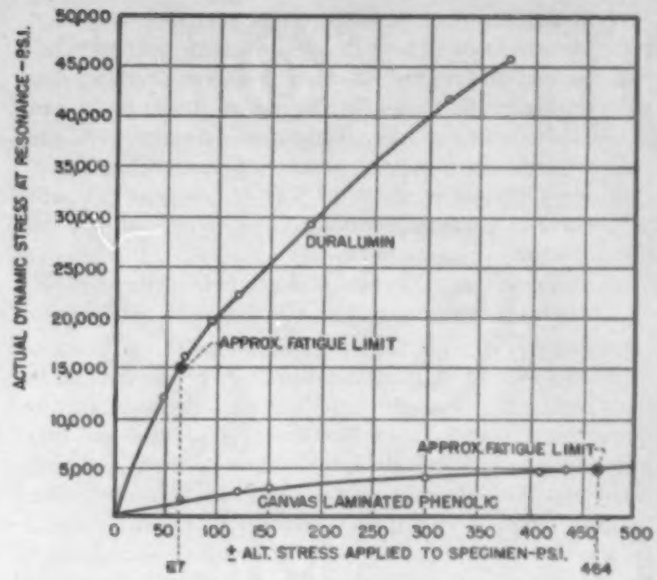
Dynamic stress = applied alternating stress × R. A. factor.

This equation holds true if the absorption of energy by extraneous damping such as air friction and dashpot damping is small. In such cases the R. A. factor is a direct measure of the increase in stress a part experiences in going through a resonant frequency. Even in cases where there is considerable extraneous damping, low R. A. factor is still very helpful in limiting resonance stresses. Some materials and structures have resonance amplifications as high as 500 or even 1000; others as low as 5. However, in most practical cases the resonance amplification varies from 5 to 50.

In choosing a material for a part which may receive near-resonance vibrations in service, it is entirely unjustified to use the fatigue strengths of materials as a sole criterion for judgment. The R. A. factor of the material must also be considered. For example, Foppl (34) has stated that "the endurance of [airplane propeller] blades depends far more on the damping capacity of the material than its fatigue strength." As a further example, the substitution of a high-strength nickel alloy steel for an ordinary mild steel for railroad bridges in a European country was accompanied by an unusual number of bridge failures—the higher R. A. factor of the alloy steel had been ignored. Similarly, engine crankshafts, overhead cables and many aircraft parts made of a high-damping material may outlast others made of a low-damping material even though its static and fatigue strengths may be relatively low.

As a final example, consider Fig. 4, which compares the resonance stresses produced in two different materials under identical alternating force. Although the dural has a direct-stress fatigue limit about 15,000/5000 or three times that of the plastic, the largest exciting alternating force (67 p.s.i.) the dural specimen can withstand without eventually failing at resonance is only 67/464 or 13.3 percent of that which this plastic specimen withstands under identical condition. This condition is due to the fact that the R. A. factor of the plastic is only 11/242 or 4.5 percent that of dural.

2. *Reduces noise*—The problem of reducing noise is generally one of minimizing vibration. Materials possessing high damping capacity are capable of dissipating considerable vibrational energy as heat, with a consequential reduction in amplitude of vibration and resulting noise. Since plastics possess an average damping capacity about ten times larger than steel, a plastic part should be considerably less noisy than a steel one, if both are subjected to the same vibratory or impact forces. A comparison between the noise made when metallic gears are meshed and that made by plastic gears indicates the significance of hysteresis damping as a noise reducer. A material which sounds dead on impact is merely one which possesses high damping.



4—Resonance stress of duralumin and of canvas laminated phenolic under identical exciting forces. The reader is referred to Reference 30 at the end of this article

3. *May indicate low notch sensitivity*—There is some experimental evidence (35) that high damping indicates low notch sensitivity or "tenderness" under dynamic stress. That is, sharp notches, rough surfaces or abrupt changes in section are more likely to result in high stress concentration in a low damping material than in a high damping material.

Compared to its beneficial effects, high damping capacity may be harmful in the following respects:

1. *Produces internal heat*—In the case of non-metallic materials, especially plastics, this temperature increase is accompanied by a decrease in strength properties. The temperature rise in rubber tires during high-speed driving, in airplane propellers or in springs may be serious enough to impose a definite limitation on operating conditions.

2. *Produces lag and distortions*—Certain types of precision measuring and indicating instruments should have low damping capacity if distortions and lag are to be kept to a minimum. For example, beryllium copper is often used for diaphragm pressure measuring springs because of low damping. Hair springs of watches and tuning forks should have low damping so that little addition of energy is required to keep them vibrating at constant amplitude.

3. *Increases shaft whirling*—Under carefully controlled conditions rotating shafts have been observed to deflect along a line at a slight angle to the direction of loading. This lateral deflection of shafts, which often results in violent whirling, is produced because the upward branch of the stress-strain curve of the material does not coincide with the downward branch. Thus, the larger the damping capacity of the shaft material the greater the whirling.

Damping capacity measurement may often be used as an effective research tool since it is an extremely sensitive index to many types of structural changes in materials. Damping measurements have been useful in exploring treatments, aging and certain other operations which affect the structure of materials.

Methods of measuring damping

The six major methods of measuring damping capacity are as follows (28, 30, 33, 34, 35): (*Please turn to next page*)

1. Measurement of the stress-strain hysteresis loop.
2. Measurement of heat developed during cyclic stress.
3. Lateral deflection method which uses an overhanging or cantilever shaft loaded with dead weights at its free end.
4. Measurement of energy output of a specimen-vibrating system excited to near-resonance by an oscillator.
5. Measurement of shape or part of complete resonance curve of a specimen-vibrating system excited by an oscillator.
6. Measurement of the rate of decay of free vibrations in a specimen-vibrating system not excited by an oscillator.

Of these six methods for measuring damping, the vibration decay method and the oscillator output energy method are the most common. Of the two, the vibration decay method requires simpler apparatus. However, for plastics and other high damping materials the rate of vibration decay is often so rapid and the difference in magnitude of alternating stress between adjacent vibrations is so large that satisfactory accuracy cannot be expected (33). A further disadvantage of the vibration-decay method is that the effects of sustained cyclic stress of constant magnitude, an important variable in many cases, cannot be readily evaluated.

Summary of available damping data

Figure 5 gives the damping capacity of several plastic materials plotted as a function of stress. Some of the published data were not included in the graph because the method of testing was such (32) that damping was measured at a very small unknown stress. The limited data available indicate that the torsional damping capacity is considerably higher than that under the same direct stress. The unfilled Bakelite resin has the smallest damping capacity of the group, with an R. A. factor exceeding 100 at low stresses. However, most of the structural laminated plastics have an R. A. factor from 7 to 18 at stress near the fatigue limit which is roughly $^1/_{10}$ that of most steels and aluminum alloys.

Dynamic modulus of elasticity

The static modulus of elasticity of a material, an index of stiffness under static loading, is defined as the ratio of the increase in stress in a material to the resulting increase in strain. There are two types of static moduli—depending upon whether the tangent or the secant of the stress-strain curve is used. The tangent modulus at a given stress is the slope of the stress-strain curve at that stress. For example, the tangent modulus at stress S_1 in Fig. 3 equals the slope of the tangent at E. The secant modulus between two stresses is the slope of the line joining the two corresponding points of the stress-strain diagram. For example, the secant modulus between stress 0 and S_t equals the slope of dotted line OA. Materials have essentially constant static moduli of elasticity with no appreciable difference between tangent and secant values in the stress range for which they reasonably obey Hooke's Law.

The dynamic moduli of elasticity of materials, an index of stiffness under dynamic loading, is defined for practical reasons as the secant modulus effective during alternating stress. Data will be presented to show that the dynamic modulus of elasticity of plastics not only differs from the static modulus but decreases rapidly with increasing alternating stress—as much as 40 percent in some cases. This concept of variable dynamic modulus carries considerable engineering significance.

One problem which requires complete data on the dynamic modulus is the determination of the cyclic stress produced by a known cyclic strain, and vice versa. This problem is closely related to a proper interpretation of fatigue testing results which is discussed in another part of this report.

Complete data on the dynamic moduli of materials are also necessary for calculating

1. Resonant frequencies in structures.
2. Stability of near-resonant vibrations.
3. Deflection constants of springs under vibrations.

Methods of measuring dynamic modulus

There are three main methods of measuring the dynamic modulus of elasticity of materials (30, 31, 36):

1. Measurement of the complete load-deflection curve or its significant points during vibration. A special case of this method includes measurement of the deflection of a rotating beam specimen.
2. Measurement of natural frequency of vibration, etc., of an isolated system under sustained near-resonant vibration in which the test specimen is the only unknown spring or deflecting member.
3. Measurement of the natural frequency, etc., of a freely decaying vibrating system in which the test specimen is the only unknown spring.

The effects of sustained alternating stress on the dynamic modulus can be determined by the first two methods but not by the third. A further disadvantage of the vibration decay method is that for plastics and other materials possessing high damping capacity the difference in amplitude of adjacent vibrations is so large that satisfactory accuracy cannot be expected.

Summary of available dynamic modulus data

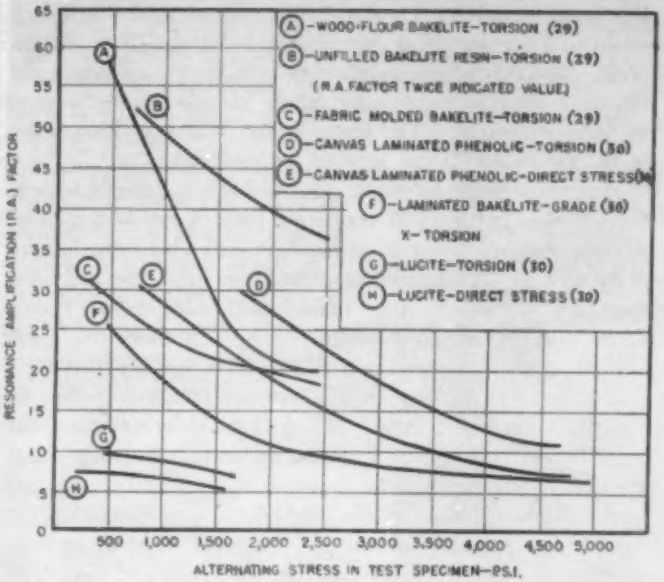
Some reasons for the deviation between static and dynamic modulus and the decrease in dynamic modulus with increasing stress are as follows:

1. *Temperature increase*—The temperature increase in materials under cyclic stress results in a change in the mechanical properties, among which is the dynamic modulus. Most metals possess comparatively low damping capacity, and therefore will not heat up as much as plastics under alternating stress. Furthermore their moduli are rather insensitive to temperature changes. The temperature of iron and steel, for example, may be increased about 70° F. before a 1 percent change in the modulus results. Thus the dynamic moduli of elasticity of most metals should not be greatly influenced by the temperature effect.

Plastics, however, heat up considerably under repeated stress as shown by Fig. 2. In addition to this, their mechanical properties are highly sensitive to temperature changes. For example, the modulus of elasticity in tension of the average phenolic plastic decreases about 30 percent as the temperature is increased from −38° to 78° F. This temperature factor causes dynamic modulus of elasticity of a plastic to be lower than static modulus, especially at high stress.

2. *Cyclic stress*—The cyclic stress accompanying a dynamic test disturbs the structure of a material. In metals, cold working causes a relatively minor change in the modulus of elasticity. In plastics, however, high cyclic stress may cause localized "fragmentation" and "deterioration" in the structure of the material, and the modulus of elasticity may be greatly reduced. The apparent modulus of elasticity in torsion of a canvas laminated phenolic was reduced from 414,000 to 337,000 p.s.i. (18 percent)[3] by an alternating

[3] Both measurements were made at same temperature.



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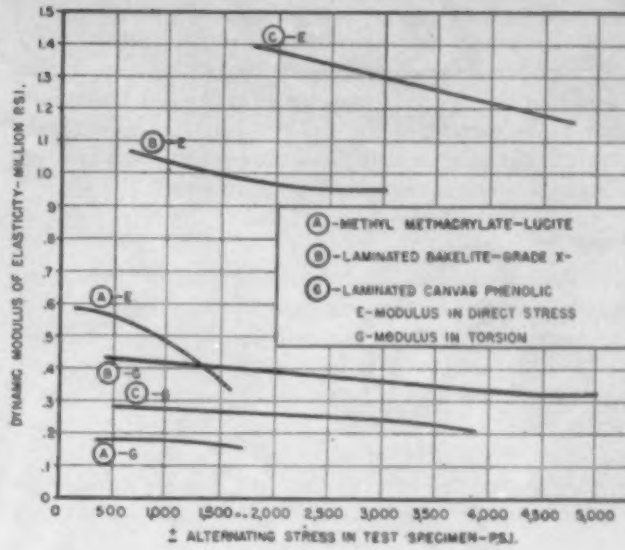

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5—Resonance amplification factors of various plastics under torsional and direct stress. Figures in parentheses correspond to references appearing at the end of this article. 6—Dynamic moduli of elasticity of plastics in direct stress and in torsion. The reader is referred to Reference No. 30 which appears at the end of the article

torsional stress of ±3000 p.s.i. which was maintained for about 40,000 cycles (30). Repeated constant-deflection fatigue tests on plastic sheets in bending also indicate a decreasing modulus in the form of a gradually decreasing load for the same deflection. Thum and Jacobi, for example, report (2) a 10 percent decrease in modulus after 20×10^6 cycles, which they attribute to deterioration and heating. Field (7) showed similar effects which he attributes to the formation of small cracks in the test specimen. Large decreases in modulus may also be expected in many plywoods under vibratory stresses which weaken the glue-bond between plies.

3. *Measurable hysteresis loop*—A material exhibiting a curved stress-strain diagram or a measurable hysteresis loop in a given stress range does not have a constant static modulus of elasticity. The variation in the tangent or secant modulus during a cycle of stress depends upon the area within the hysteresis loop and therefore increases with increasing magnitude of stress.

The dynamic modulus of elasticity for a given stress cycle, which associates the alternating stress with the corresponding alternating strain, is the secant modulus defined previously. In reporting static moduli of elasticity, it is customary to specify the tangent modulus at zero stress, which is usually higher than the secant modulus[4] (Fig. 3).

4. *Rate of load application*—The rate of load application is generally higher during alternating load than in the usual static test. Although the moduli of metals are not generally affected by rate of load application, many non-metals show an increase in modulus with increasing rates of load application.[5] Static flexure tests on Lucite, for example, indicate an 18 percent increase in tangent modulus at zero stress if the rate of straining is increased from 0.028 to 0.050 in./min. Tension tests on a laminated phenolic show a 7 percent increase in modulus of elasticity if the loading rate is increased from 14.22 to 284.0 p.s.i./sec. (2).

The load rate may be very rapid during a fatigue test. Assuming an alternating stress of 10,000 p.s.i. is applied at 1800 r.p.m., the maximum rate of load application is 1,880,000 p.s.i./sec. and mean rate is 1,200,000 p.s.i./sec. However, the effect of speed is not as serious as might appear, since at high loading rates where creep is very small, the modulus is probably quite insensitive to changes in loading rates. Nevertheless, it is not reasonable to expect, without investigating the material under consideration, that the modulus of elasticity obtained during a slow static test applies to the high rates of loading encountered in many dynamic tests.

5. *Thermodynamic state of specimen*—Considering the thermodynamic state of the specimen, the static modulus of elasticity is an isothermal or constant temperature value, whereas the dynamic modulus is an adiabatic or constant heat value. Since the adiabatic modulus of most structural materials is less than 1 percent higher than the isothermal value, this effect is small in comparison with the others mentioned.

In summarizing the significant differences between the static and dynamic moduli, the first three factors mentioned—heating, deterioration and Hooke's Law deviation (all of which depend on damping capacity)—tend to produce a lower dynamic modulus, whereas the fourth factor—loading speed (partially dependent on creep characteristics)—tends to increase the dynamic modulus.

The combined effects of these four factors are generally quite small for steel and other low damping materials. For example, the dynamic modulus of elasticity of mild steel and dural vibrating at low stress at about 25,000 cycles per sec. is within 2 percent of its static value (31). Some high damping metals, however, display a significant deviation between static and dynamic modulus. The dynamic modulus of magnesium alloy "M" was 20 percent lower than its static value at high cyclic stresses. As a group, plastics display the largest difference in the two moduli. The difference may be as large as 40 percent in Lucite, and as large as 30 percent in grade "X" laminated Bakelite and canvas laminated phenolic.

For most materials, the higher the stress the lower is the dynamic modulus of elasticity. Limited data showing this relationship are plotted in Fig. 6 for a few materials under

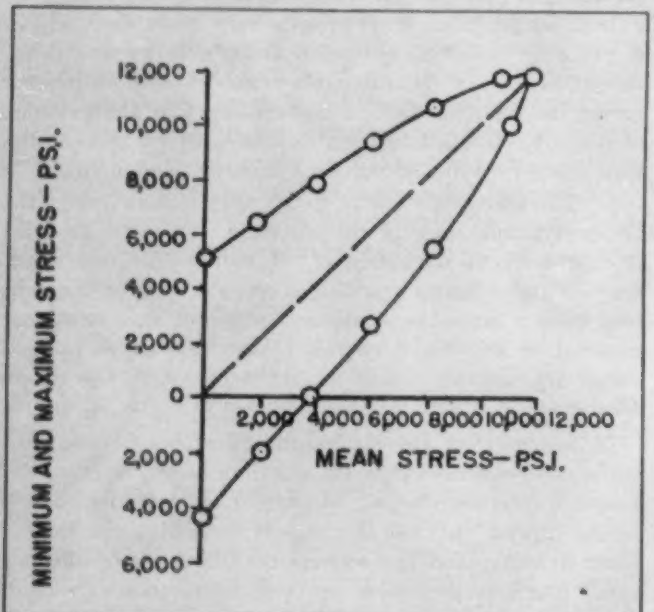
[4] Exceptions to this statement include many rubbers which display increasing tangent moduli up to certain stresses.
[5] This increase in static modulus is probably associated with the large creep generally observed in plastics.

direct and torsional vibrations. These data were obtained by the sustained near-resonance vibration method (30). By extrapolating these experimental curves to zero, it may be seen that the dynamic modulus at zero stress is generally within a few percent of the static values. In general, the higher the damping capacity of a material the greater is the deviation between static and dynamic modulus.

Fatigue

The fatigue strength of a material or a structure is determined by repeating a known constant alternating force enough times to produce failure. In specifying the fatigue strength, S_a of Fig. 1, both the mean stress S_m and the number of cycles N to failure should be given. The term "endurance" is sometimes used in place of "fatigue" because it is somewhat more descriptive of the mode of failure. That is, materials do not fail because they get tired or fatigue, but rather through the progressive growth of a crack which begins and spreads under the influence of alternating stress. Nevertheless, common usage generally dictates conforming to the word "fatigue."

Fatigue data are usually represented by the S–N curve, which is a plot of the fatigue strength versus the number of cycles required to produce failure (generally a semi-logarithmic plot). Typical S–N curves for three plastics are shown in Fig. 8. For stresses in the fatigue range, the lower the repeated stress, the greater is the number of cycles to failure.



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For many materials this trend continues as shown in Fig. 8 down to a certain point, hereafter called the S–N transition point, beyond which further reduction in amplitude of dynamic stress will not cause failure even if the test is continued indefinitely. The stress at the S–N transition point is defined as the fatigue limit of the material.

Many materials do not appear to have a definite fatigue limit. That is, the S–N transition point is not well defined in the range investigated, or the S–N curve may continue to drop beyond an apparent transition point. For example, the S–N curve for resin-impregnated compressed yellow birch under alternating bending shows no transition point even though the tests were carried to 500×10^6 cycles (18).

In many practical cases, the number of stress cycles imposed on a structure during its service life is far less than that corresponding to the S–N transition point. In such cases, the fatigue strength of the material at the number of stress cycles corresponding to the life of the machine, and not necessarily the fatigue limit, is the best criterion of suitability. Considering the three phenolic resins of Fig. 8, an extreme example, the pure resin has the highest fatigue limit, and is therefore the best of the three for withstanding loads that are repeated over one million times. The wood-flour plastic is best under stress repeated between 30,000 and 1,000,000 while the cellulose fiber filled plastic, which has the lowest fatigue limit, is the most satisfactory for cyclic stress repeated less than 30,000 times.

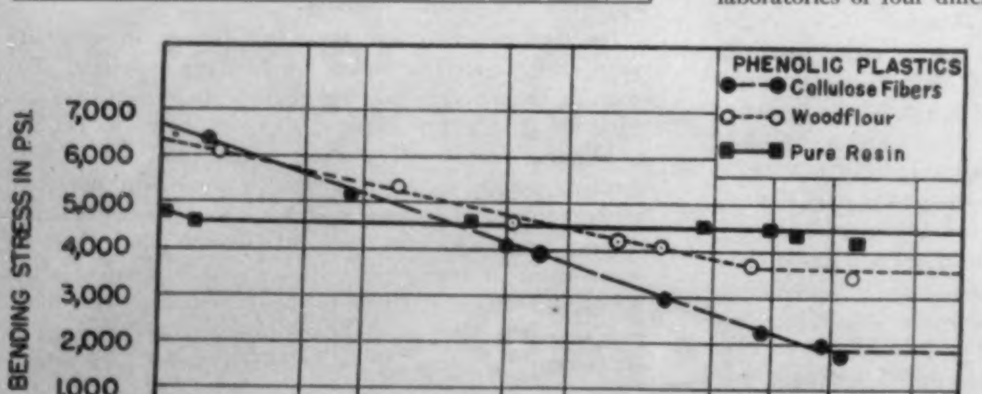
In many applications the dynamic forces are superimposed over static preload. Data showing the effect of mean static preload S_m on the fatigue strength S_a are contained in stress-range diagrams, such as Fig. 7. The maximum and minimum stress during the cycle, plotted with the mean stress as a variable, shows the manner in which the permissible alternating load decreases as the static preload increases. In spite of the usefulness of stress-range diagrams, very few have been published for plastic materials.

Methods of fatigue testing

Three types of fatigue machines have been used for testing of plastics.

1. Rotating beam type.
2. Repeated-constant-deformation crank type.
3. Repeated-constant-force oscillator type.

The rotating beam machine has been used for the fatigue testing of plastic materials by Riechers (4), Field (7), Gough and Cockroft (14), Wegelius (17), and Fuller and Oberg (18). This is only a partial list, yet it represents the work done in laboratories of four different countries and shows that this



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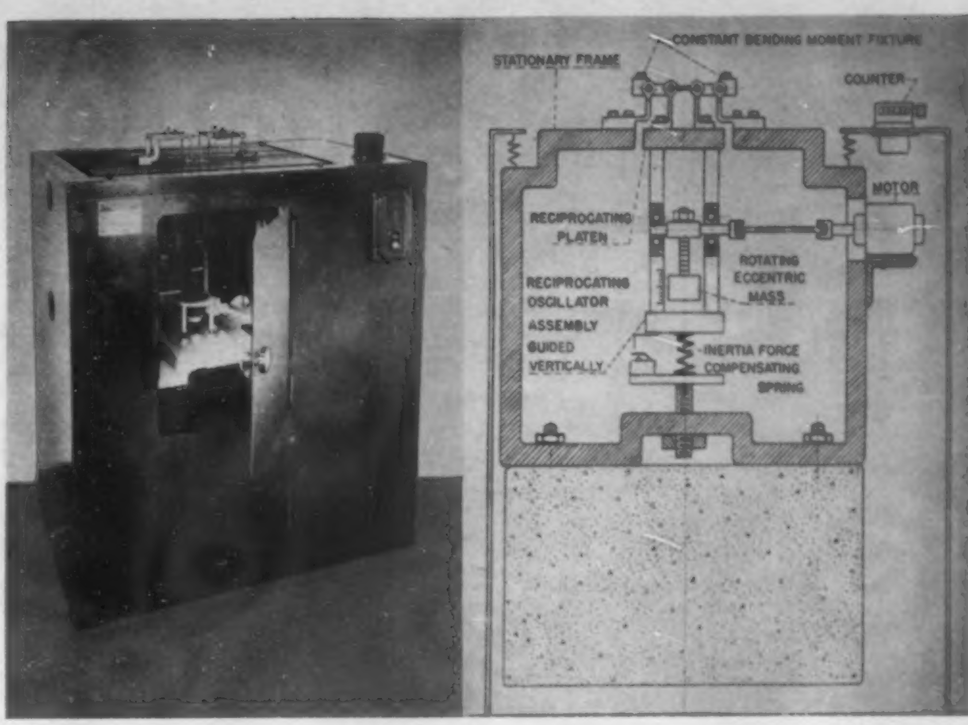
7—Stress-range diagram for phenolic resin with cellulose fiber filler. Reference No. 3 at the end of this article deals with this subject. 8—S-N curves for three plastics. The reader is directed to Reference No. 2 in this story



9—Photograph and drawing of a repeated-constant-force oscillator type of fatigue machine. A special inertia force compensating device in this machine overcomes difficulty of unknown stresses in the specimen attributable to proximity to resonance. Drawing on the right shows an arrangement for testing flat specimens under constant bending moment with a fixture for plastic sheets

type of machine is one of the most widely accepted methods of fatigue testing of round specimens.

Outstanding characteristics of this machine include its simplicity and a high maximum operating speed, which shortens the duration of the test. Nevertheless, it should be recognized that the unit possesses three inherent disadvantages when used for testing plastics. It is limited to round specimens although plastic sheets or other shapes must often be tested without disturbing the surface. In addition the machine can be used for bending tests only; and it is applicable only for tests under zero mean stress. Consequently, other methods of fatigue testing must often be employed for plastics.

In the repeated-constant-deflection machine the test specimen is subjected primarily to constant alternating deflection (not necessarily constant alternating force) by an adjustable crank which transforms the rotary motion of the driving motor into reciprocating motion. This alternating bending deflection can be superimposed on any desired mean deflection by statically preloading the specimen. This type of fatigue testing machine was described by K. Matthaes (24) and used by O. Kraemer for his tests on plywoods (16). Thum and his co-workers in their extensive tests on numerous plastic materials (1), Field (7), Findley (8, 9), D. W. Brown (10), Dietz and Grinsfelder (19, 20), and others. It has recently been proposed to the American Society of Testing Materials as a tentative method for repeated flexural fatigue testing of plastics (23).

In the repeated-constant-force oscillator type of fatigue machine the test specimen is subjected to a constant alternating force by a mechanical oscillator which utilizes centrifugal force produced by an eccentrically supported rotating weight. This alternating force may be superimposed over a static preload applied by a flexible prestress spring. The oscillator type fatigue machines have been very widely used in Germany for fatigue testing of specimens and structures (22) and by Thum and Jacobi to obtain S–N curves for various phenolic plastics under tension-compression (2).

The main factor limiting the applicability of the oscillator type of fatigue machine in the past has been the difficulty in avoiding inertia effects due to near-resonance vibrations when testing flexible specimens. That is, although these machines were very satisfactory for relatively stiff specimens, such as tension-compression specimens, it was difficult to eliminate unknown inertia forces when testing flexible specimens such as plastic sheets, etc., in bending.

This difficulty of unknown stresses in the specimen due to proximity to resonance has recently been overcome in the commercially available machine shown in Fig. 9, by a special inertia force compensating device. The alternating force is produced by a rotating eccentric mass supported within the reciprocating assembly, which is guided so that it can vibrate in a vertical direction only. The compensator spring absorbs all the unknown inertia force due to the motion of the reciprocating assembly. Thus, irrespective of the specimen deformation, the load in the specimen equals that produced by the rotating eccentric and remains constant during the test. Figure 9 shows an arrangement for testing flat specimens under constant bending moment with a fixture for plastic sheets. Other fixtures which bolt to the reciprocating platen and stationary frame accommodate fatigue tests in torsion and direct stress.

Comparison of testing machines

The oscillator type of fatigue machine differs basically from the crank type in that it produces repeated constant stress instead of repeated constant strain. For materials such as metals for which the dynamic modulus of elasticity equals the static value and does not change under cyclic stress, there is little difference between data obtained by both machines. However, for materials like plastics for which the stress produced by a given strain applied statically may differ greatly from that under dynamic conditions, the two tests may yield widely different results. On the basis of data presented in the section on dynamic modulus of elasticity, the difference may be as large as 40 percent.

Some of the complications and inaccuracies in fixed strain fatigue testing would be eliminated if the data obtained with such machines were presented in terms of strain, without attempting to convert them to stress values. Dietz and

TABLE I.—SUMMARY OF BENDING FATIGUE DATA OF PLASTIC MATERIALS
Unnotched specimen under reversed stress

Material	Specific gravity	Testing temp.	Mean static modulus of rupture	Mean elastic modulus	Fatigue testing machine	Testing speed	Fatigue specimen shape	Bending fatigue strength	Number of cycles	Endurance ratio S_a/S_b	Ref no.
		°F.	p.s.i. S_b	MM p.s.i.		cycles per min.	size in in.	p.s.i. S_a	MM		
Phenolic resin with fine-grained woodflour	1.37	Room	10,600	1.06	A	1,500	Flat, 0.2 thick	3,620	20	0.34	3
Phenolic resin with shredded fabric	1.39	Room	7,800	1.06	A	1,500	Flat, 0.2 thick	3,480	20	0.43	3
Phenolic resin with cellulose fibers	1.38	Room	8,170	1.06	A	1,500	Flat, 0.2 thick	1,950	20	0.24	3
Phenolic resin with laminated cloth	1.30	Room	18,100	1.14	A	1,500	Flat, 0.2 thick	4,320	20	0.24	3
Phenolic resin with long cloth and paper fibers	1.40	Room	16,400	1.92	A	1,500	Flat, 0.2 thick	5,100	20	0.31	3
Pure phenolic resin	1.27	Room	14,900	0.85	A	1,500	Flat, 0.2 thick	4,550	20	0.31	3
Phenolic resin with felted asbestos filler	1.61	Room	22,100	1.46	A	1,750	Flat	6,500	1.7	0.29	7
Phenolic resin with cotton fabric (Grade L)	1.33	Room	21,400	1.36	A	1,750	Flat	7,000	1.6	0.33	7
Phenolic resin with cross-banded high-strength paper	1.40	Room	27,350	1.69	A	1,750	Flat	8,000	0.6	0.29	7
Phenolic resin with cross-banded high-strength paper	1.40	Room	29,700	1.79	B	10,000	Flat	6,500	250	0.22	7
Phenolic resin with unidirectional high-strength paper	1.35	85	....	..	A	1,750	Flat	8,500	1.25	..	7
Lam. phenolic Grade L fabric, longit. loading	1.34	80	21,400[d]	1.60	B	E	Round C	5,000	100	0.23	6
Lam. phenolic Grade L fabric, longit. loading	1.34	−32	24,800[d]	1.705	B	E	Round C	6,600	100	0.27	6
Lam. phenolic Grade L fabric, transv. loading	1.34	80	18,200[d]	1.11	B	E	Round C	4,000	100	0.22	6
Lam. phenolic Grade C fabric, longit. loading	1.34	80	21,400[d]	1.22	B	E	Round C	4,700	100	0.22	6
Lam. phenolic Grade C fabric, transv. loading	1.34	80	16,300[d]	1.00	B	E	Round C	3,500	100	0.21	6
Lam. phenolic Grade XX, paper long. loading	1.34	80	18,400[d]	1.64	B	E	Round C	5,200	100	0.28	6
Lam. phenolic Grade XX, paper transv. loading	1.34	80	16,100[d]	1.31	B	E	Round C	5,200	100	0.32	6
Synthetic resin paper	..	Room	42,500	1.78	..	....	....	7,100	0.5	0.17	4
Synthetic resin fabric	..	Room	20,500	0.94	..	....	....	2,800	0.8	0.14	4
Cast phenolic plastic	1.36	80	12,050[d]	..	B	E	Round C	4,200	100	0.35	6
Unidirectional glass cotton laminate	1.67	Room	60,500	2.4	A	1,750	Flat	12,500	100	0.21	7
Cellulose acetate	1.30	80	4,900[d]	0.22	B	E	Round C	1,000	100	0.20	6
Cellulose acetate, not aged	1.18	Room	....	0.24	A	1,750	0.3 thick × 0.5	1,100	10	..	9
Cellulose acetate, aged 11,000 hr.	1.18	Room	....	0.24	A	1,750	0.3 thick × 0.5	1,380	10	..	9
Cellulose acetate, aged 14.00 hr.	1.18	Room	....	0.24	A	1,750	0.29 dia.	1,450	10	..	9
Methyl methacrylate resin, Lucite	1.18	80	11,370[d]	0.38	B	E	Round C	2,000	10	0.19	6
Methyl methacrylate resin, Lucite	1.18	−31	18,300[d]	0.66	B	E	Round C	4,800	10	0.26	6
Resin-bonded birch plywood, in direction of fibers	...	Room	13,600	..	A	....	Flat, 0.165 thick	3,550	...	0.26	19
Resin-bonded birch plywood, at 45° to fibers	..	Room	5,100	..	A	....	Flat, 0.165 thick	2,800	...	0.52	19
Casein-bonded birch plywood, in dir. of fibers	..	Room	17,200	..	A	....	Flat, 0.14 thick	4,280	...	0.25	19
Casein-bonded birch plywood, at 45° to fibers	..	Room	4,660	..	A	....	Flat, 0.14 thick	1,210	...	0.26	19
Two-ply laminated birch (phenol-formaldehyde glue)	0.67	Room	25,500	2.4	A	1,750	Flat	6,400	2	0.25	22
Three-ply laminated birch (phenol-formaldehyde glue)	0.68	Room	23,400	2.1	A	1,750	Flat	5,620	2	0.24	22
Three-ply plywood birch (phenol-formaldehyde glue)	0.72	Room	20,700	2.1	A	1,750	Flat	5,180	2	0.25	22
Three-ply plywood birch (urea-formaldehyde glue)	0.66	Room	17,400	2.0	A	1,750	Flat	4,350	2	0.25	22
Compressed plywood	..	Room	....	..	B	....	0.61 dia.	5,460	10	..	20
Compressed laminated resin impregnated wood	..	Room	45,000	..	A	....	0.5 × 0.5 sq.	11,000	...	..	22
Compr. lam. resin impreg. wood (maple) 23 percent phenolic resin	1.31	Room	50,800	2.9	B	3,450	0.33 dia.	10,000	200	0.20	21
Compr. lam. resin impreg. wood (maple) 23 percent phenolic resin	1.31	Room	50,800	2.9	B	10,600	0.33 dia.	9,500	200	0.19	21
Compr. lam. resin impreg. wood (maple) 23 percent phenolic resin	1.31	Room	38,000	2.9	B	1,200	1.0 dia.	7,500	100	0.20	21
Compr. lam. resin impregn. wood (birch) 35 percent phenolic resin	1.25	Room	36,600	..	B	10,600	1.0 dia.	9,000	500	0.25	21

A.—Repeated constant strain machine.
B.—Rotating beam machine.
C.—Machined from 1/2 in. flat material.
E.—3450 or 10,600 c.p.m.
[d] Of 1/2-in. thick specimen.

Grinsfelder (20) present some of their S–N curves for plywoods in terms of alternating strain. Duggan and Fligor (11), in reporting tests on plastic sheets with a special constant strain machine known as the de Matt'a flexing machine, give their fatigue data in terms of repeated bending strain.

One phase of the repeated constant deflection fatigue test of plastics on which there is little uniformity is the criterion for determining failure. Most fatigue machines of this type are built to stop the test when the specimen actually separates. However, DeBruyne (14) and others emphasized the fact that under repeated constant strains plastic specimens, especially the laminates, may continue to hold millions of cycles after a split has first appeared. Thus, there is general agreement with respect to considering that failure has occurred long before the specimen has completely separated. But that is where the agreement ends. Dietz and Grinsfelder (20) did not wait for the specimen to separate, but allowed the crack to form completely across the width before considering the specimen broken. D. W. Brown (10) defines fatigue fracture at the appearance of the first crack. Thum and others, in an early report (1), considered fracture had occurred when the crack had progressed to one-half the depth of the specimen. However, in later work (2), failure was arbitrarily defined as the point where the decrease in stress under repeated constant deflection reached 140 lb. per sq. inch. Riechers (4) stopped his fatigue tests every 50,000 cycles, and considered the specimen had failed when a decrease in static modulus appeared. Field (7) defines failure in a similar manner by his deflection method. He found that for a paper-laminated phenolic, the strengths obtained by the "first visible crack" method were 20 percent higher at 50,000 cycles and 9 percent higher at $^1/_2$ million cycles than those obtained by the deflection method.

In general, a member subjected to repeated stresses in service is no longer useful the instant a fatigue fracture starts. Thus, the method of Riechers and Field appears to be the most satisfactory, although it does complicate the test procedure.

It should be noted that the constant-stress-fatigue machines, such as the rotating beam and oscillator type, dispense with the difficulty in defining the point of failure. When a fracture starts, the effective specimen area decreases, causing an increase in unit stress which accelerates the progress of the fracture. These machines incorporate an adjustable cut-off switch which stops the machine when a predetermined deflection is reached. Since there are relatively few cycles between the start of failure and actual separation of the specimen in such machines, the setting of the cut-off switch has practically no effect on the total number of cycles to failure.

In view of the variable dynamic modulus of elasticity of plastics and the difficulty in defining failure, the crank-type machine would be expected to give higher strength values than the fixed-force machine. Although general comparisons seem to indicate this trend, a direct evaluation of this machine effect has not yet been made although it is under way.

One question that often arises is, "Which of these two tests is more significant?" Both tests yield valuable information, providing that the test data are interpreted properly. In some applications, such as cam springs, relay springs and shoe soles, the part is subjected primarily to deformations of a certain amplitude, and it is the ability of the member to withstand these strains that measures its serviceability. In such cases, data obtained on the constant deformation type of machine are generally more valuable in guiding the designer, although the value of the alternating force must often be known. However, in most practical applications, members are subjected primarily to repeated stresses rather than repeated strains. For example, inertia forces, gas pressures and aerodynamic effects exert forces rather than deflections on such parts as airplane propellers, tabs, wings, engine crankshafts, bearings, etc. Such applications require strengths obtained on a repeated constant stress basis.

It should again be emphasized that constant strain data converted to a stress basis should be used with extreme caution since the fatigue strengths so determined may be higher than the actual resistance of the material to alternating stress. In order to simulate constant repeated force conditions with the crank-type machine, the procedure of stopping the test and readjusting the crank to maintain a constant alternating force, measured statically, has been used. However, this does not correct for difference between static and dynamic moduli.

Effect of specimen temperature on fatigue

A serious difficulty often encountered in the fatigue testing of plastics is their temperature increase which was explained previously (Fig. 2). The ability of a plastic to withstand repeated stress is generally reduced by an increase in temperature. For example, the decrease in fatigue limit between -30 and 80° F. is 58 percent for Lucite and 25 percent for a fabric laminated phenolic (6). Consequently, the apparent fatigue strength is lower than the true room-temperature strength of the specimen. Any factor which affects the difference between specimen and room temperatures will influence the results. The following factors are significant in this connection.

1. High testing speeds result in a greater rate of internal heat generation due to damping, which in turn increases the specimen temperature. However, high speeds reduce testing time and thus a compromise is necessary.
2. Large specimens tend to run hotter than small specimens, since they generally possess less conducting surface per unit volume.
3. The percentage of fibers in the test specimen subjected to high stress affects the rate of heat generation and temperature. Therefore, a direct stress specimen in which all fibers are subjected to the peak stress will run hotter than a bending specimen where relatively few fibers are subjected to high stress. Furthermore, in the flexure test the highly stressed outer fibers are situated externally for good heat dissipation.
4. Since the damping under torsional stress is much higher than that under the same direct stress (25), torsional fatigue tests may be expected to run considerably hotter than direct stress and bending tests.
5. Any other factors which affect the rate of heat conductivity from specimen to environment—such as forced air stream or type, orientation and shielding of specimen—will affect the temperature during the test. For example, higher testing speeds are possible in the rotating beam machine because the rotation of the specimen provides better cooling.

Errors in bending equation

The fact that the dynamic modulus of elasticity of plastics decreases appreciably with increasing stress introduces a significant error in interpreting flexural fatigue data. In calculating the maximum fiber stress that causes failure, the simple equation $S = Mc/I$, is used. Although this equation does not involve the modulus of elasticity directly, its derivation assumes that the stress is proportional to the neutral axis distance, which in turn assumes that the modulus

of the material is constant at all stresses. Since the modulus of plastics decreases as the stress increases, the outside fibers under the highest stress are relatively less rigid than the average fiber in the specimen, and hence are subjected to a lower stress than that represented by $S = Mc/I$. Therefore, the reported bending fatigue strengths are higher than the true strengths of the specimen. By following a similar reasoning, it can be shown that this error is greater for round bending specimens than it is for rectangular bending specimens. This factor accounts for at least part of the 20 percent difference between the bending fatigue strength of a circular and a rectangular specimen of cellulose acetate (9).

Notch sensitivity

The stress concentration introduced by a notch or hole—often called notch sensitivity—seriously reduces the load carrying capacity of a member, especially under alternating stress. Thum and Jacobi (2) report a 15 to 33 percent decrease in fatigue strength due to the stress concentration of a 5-mm. diameter hole in a flat phenolic specimen, and conclude that laminates appear to have smaller notch sensitivity than the woodflour base phenolics. Rotating beam fatigue data by Oberg and others (6) reveal that adding a V-notch to the specimen reduces the fatigue strength of various fabric and paper laminated phenolics from 0 to 36 percent. Cast phenolic and cellulose acetate are weakened 52 (6) and 53 (8) percent, respectively, by a V-notch, whereas Lucite is very unusual in that a notch increases its strength by 30 percent (6, 30). The effect of notches on rotating-beam compressed-plywood specimens was studied by Wegelius (17) who reports a 14 percent weakening due to fillets of 0.5 to 2.0 mm. radius. Fuller and Oberg (18) observed a 10 to 21 percent decrease in strength in compressed laminated woods due to V-notches in a rotating beam specimen.

Effects of understressing and overstressing

Fatigue data on metals show that sustained cyclic stress below the fatigue limit may strengthen the material slightly, whereas high cyclic stress generally weakens the material. Data on the effects of understressing and overstressing of plastics are very inadequate. A few tests by Thum (2) indicate that repeated stress below the fatigue limit does not increase the fatigue limit. Field (7) reports that repeated stress well above the fatigue limit does, in general, decrease the static strengths and probably has a similar effect on the fatigue strengths.

Effects of speed of testing

Published data reveal that the speed of testing up to 10,000 r.p.m. does not seriously affect the fatigue strength of metal. The limited data available for plastics indicate a similar conclusion, provided temperature effects can be eliminated. Repeated-constant-deflection tests reported by Thum and Jacobi (3) show no change in fatigue limit between 600 and 3000 r.p.m. Rotating beam tests on compressed laminated woods (18) indicate a relatively small decrease in fatigue limit results from increasing testing speed from 3450 to 10,600 r.p.m. Speed effects reported for repeated-constant-deflection tests on cellulose acetate (9) appear, in reality, to be temperature effects.

Summary of fatigue data

A summary of some of the published fatigue strengths of plastic materials under reversed bending stress is presented in Table I. The endurance ratio of a material is the ratio between its fatigue limit and its static ultimate strength under the same type of load. The endurance ratio of the various plastic materials listed in the table varies between 0.20 and 0.35 except for a few extremes. However, static tests should not be considered as a method of securing fatigue data, since recorded endurance ratios vary between wide limits. Furthermore, fatigue strengths are more susceptible than static strengths to manufacturing conditions such as curing pressure, temperature and time.

Tension-compression and torsional fatigue data obtained thus far are too inadequate for generalized conclusions. On the basis of the few data presented for phenolic laminates (2), the strength under direct stress is 35 to 45 percent higher than the bending strength, and the torsional strength is one-half to one-third the bending strength. These relationships may in part be explained by the low shear strength of the bond between laminations and are probably quite inaccurate for the non-laminates.

Acknowledgments

The authors gratefully acknowledge their indebtedness to Alfred Sonntag for his interest, advice and aid during the preparation of this paper.

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Fatigue of plastic materials

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TECHNICAL BRIEFS

Abstracts of articles on plastics in the world's scientific and engineering literature relating to properties and testing methods, or indicating significant trends and developments.

Engineering

PLASTICS — PREVENTION OF THE FIRE HAZARDS. R. R. Fleck, Fire *36*, 129-30 (Jan. 1944). The plastics industry is concerned with organic materials which are usually combustible. In general, thermoplastic materials are more hazardous than thermosetting plastics. Cellulose acetate plastics may burn vigorously, the rate being dependent upon the plasticizer. Methyl methacrylate plastics burn quietly at first, then more vigorously as the heat depolymerizes the resin. Sources of hazard are gas-heated ovens, static electricity generated during polishing procedures, and frictional sparks resulting from metallic particles during grinding operations. It is recommended that officials and personnel be trained to reduce sources of fire and to fight these fires effectively. The use of inert organic liquids and general cleanliness in the plant are stressed.

SULFUR AND THIOKOL MAKE ACID-PROOF CEMENT. Chemical Industries *54*, 519 (Apr. 1944). It has been found that sulfur and Thiokol may be combined to make acid-proof cements. The strength of these cements is comparable with that of concrete. These cements are suitable for bonding metal and ceramic surfaces. The coefficient of thermal expansion is about one-third that of ordinary sulfur cements. These cements are inert up to 200° F. and are unaffected by hot acids, cold acids, corrosive salts and mild alkaline solutions. They are also impervious to liquids. The bond strength to brick is between 400 and 500 lb./in.^{2} They are being used in the construction of pickling tanks, chemical vats and industrial sewers. The cements are of the hot-melt type.

EXPANDED PLASTICS. British Plastics *16*, 63-5 (Feb. 1944); Plastics *8*, 55-6 (Feb. 1944). Four types of plastics are being manufactured in expanded form in England. The expanded phenol-formaldehyde resin has an apparent density range of 7 to 30 lb./ft.^{3} The thermal conductivity of the 7 lb./ft.^{3} material is 0.28 Btu./ft.^{2}/in./°F., while the compressive strength is 100 p.s.i., the tensile strength is 200 p.s.i., the impact strength is 0.10 ft.-lb./in. and the modulus of elasticity in compression is 4,000 p.s.i. The expanded polyvinyl formal has an apparent density range of 6 to 30 lb./ft.^{3} The thermal conductivity of the 6 lb./ft.^{3} material is 0.24 Btu./ft.^{2}/in./°F., the compressive strength is 170 p.s.i., the tensile strength is 340 p.s.i., the impact strength is 2.46 ft.-lb./in. and the modulus of elasticity in compression is 10,000 p.s.i. The apparent density of the expanded polystyrene ranges from 2 to 20 lb./ft.^{3} The thermal conductivity of the 3 lb./ft.^{3} material is 0.22 Btu./ft.^{2}/in./°F., the compressive strength is 50 p.s.i., and the tensile strength is 100 p.s.i. The apparent density of the expanded polyvinyl chloride ranges from 10 to 20 lb./ft.^{3} These expanded plastics are being combined with more dense facing materials such as plywood, sheet asbestos and dural to make useful products. Expanded plastics find applications as thermal insulating materials for refrigerators, ships, hospitals and low-temperature plant equipment, as light-weight construction materials for aircraft struts, wireless masts, tail-fairings, flooring, partition walls and instrument panels, as elastic stabilizing media in building construction for wall panels, floors, ceilings and doors, and as buoyant materials for use in buoys, floats, pontoons and life-saving apparatus.

To offset wartime restrictions upon the use of paper, Technical briefs, Plastics digest, U. S. Plastics Patents and Books and booklets will henceforth be printed on a lighter stock. The use of this lighter weight paper has even made possible an increase in the number of pages devoted to these departments. Any one desiring extra copies of the following 8 pages may have them free of charge.

Chemistry

FIXATION OF ACETONE AND WATER ON CELLULOSE ESTERS AND ETHERS. L. Clement and C. Rivière. Bull. soc. chim. *10*, 386-96 (1943); Chem. Ab. *38*, 2817 (June 10, 1944). Cellulose derivatives were immersed for several days in various mixtures of water and acetone (10 g. to 100 ml.). The liquids were removed from the solids by pressing out in stages and the compositions determined from the densities. The amounts of water and of acetone absorbed were determined from the compositions of the liquids. When plotted against the volume extracted, the compositions of the expressed liquids obtained from one initial mixture lie on a straight line and compound formation is shown by the convergence of the lines for several mixtures. The point of convergence was calculated from the equation of the straight lines. Each cellulose derivative formed two compounds. The molecular compositions are as follows: 1 cellulose nitrate : 2.2 acetone; 1 cellulose nitrate : 1.1 acetone; 2 cellulose acetate : 3 acetone; 1 cellulose acetate : 3 acetone : 8 water; 1 cellulose triacetate : 3 acetone; 1 cellulose triacetate : 1.5 acetone; 2 ethyl cellulose : 3 acetone; 4 ethyl cellulose : 3 acetone : 8 water; 1 benzylcellulose : 2 acetone; 1 benzylcellulose : 1 acetone : 2 water.

INTERMOLECULAR FORCES AND CHAIN CONFIGURATION IN LINEAR POLYMERS. THE EFFECT OF N-METHYLATION ON THE X-RAY STRUCTURES AND PROPERTIES OF LINEAR POLYAMIDES. W. O. Baker and C. S. Fuller. Ann. N. Y. Acad. Sci. *44*, 329-49 (Nov. 12, 1943). Nine N-methylated polyamides, with methyl substitution varying in polydecamethylene sebacamide from 0 to 55 mol percent, were studied. The properties representing the gross solids were Young's modulus, moisture sorption and relative solubility; the corresponding fine structure was studied by x-ray diffraction from oriented and unoriented sections. The elastic modulus decreases with increasing N-methylation; relative solubility and moisture adsorption increase. The interchain spacings are not changed by the methyl substitution, but one of the principal spacings (3.76 A) becomes diffuse with higher amounts of substitution. The chains appear retracted by partial folding along the fiber axis.

THE ELECTRON DIFFRACTION BY AMORPHOUS POLYMERS. G. D. Coumoulos. Proc. Roy. Soc. A *182*, 166-79 (Dec. 16, 1943). The electron diffraction patterns of vinyl acetate, acrylate and methacrylate polymers show that the structure consists of a long zigzag chain of carbon atoms with side-chains alternately on the right and the left of the zigzag chains and on planes approximately perpendicular to the axis of the main chain. The long zigzag chains have a 1, 3 structure. The side chains are subject to lateral cohesive forces which group them in clusters. In the clusters the side-chains tend to arrange themselves parallel to one another. The multilayer pattern indicates a certain orientation of the side-chains with a large number grouping together. The patterns indicate an amor-

phous character which is attributed to the tendency of the side-chains to pack closely in clusters, which distorts the main stem and thus prevents alignment.

Properties

THERMAL EXPANSION AND SECOND-ORDER TRANSITION EFFECTS IN HIGH POLYMERS. I. EXPERIMENTAL RESULTS. R. F. Boyer and R. S. Spencer. J. Applied Physics *15*, 398-405 (Apr. 1944). Experimental values of second-order transition temperatures and of cubical expansion coefficients below and above this temperature are presented for several new materials, including saran. The thermal expansion behavior of two-component systems of incompatible materials, polystyrene plus polyolefins, has been studied. For relatively coarse dispersions (1000° A), the second-order transition temperature is 82° C., independent of composition, while the difference in cubical expansion coefficient above and below the transition temperature is directly proportional to the volume fraction of polystyrene in the mixture. Unplasticized saran behaves similarly in that the second-order transition temperature is constant while the difference in cubical expansion coefficient decreases linearly with increasing crystallinity. For molecular dispersions of incompatible materials, both the transition temperature and difference in cubical expansion coefficient are functions of composition. It is shown that for most high polymers the second-order transition temperature increases with increasing intermolecular force constants, while the product of the transition temperature and cubical coefficient of expansion above the transition temperature is roughly constant (0.1 to 0.2).

ELASTO-VISCOUS AND STRESS-OPTICAL PROPERTIES OF COMMERCIAL POLYMERIZED METHYL METHACRYLATE AS A FUNCTION OF TEMPERATURE. H. A. Robinson, R. Ruggy and E. Slantz. J. Applied Physics *15*, 343-51 (Apr. 1944). The elasto-viscous and stress-optical properties of commercial methyl methacrylate have been measured. Between 66 and 107° C., Young's modulus drops from approximately 400,000 p.s.i. to roughly 200 p.s.i. and the material behaves like rubber. At 93°C. the viscosity is approximately 10^{13} poises. This drops to 10^{8} poises at 177° C.

DUCTILITY OF SYNTHETIC-RESIN FILMS. W. Fischer and E. Witte. Kunststoffe *32*, 110-12 (1942). Tensile stress-elongation curves were obtained for polystyrene, polyvinyl chloride, cellulose acetate, and polyamide films. The curves showed that the stress-elongation behavior of polystyrene, polyvinyl chloride and cellulose acetate were similar and that the behavior of polyamide was different from the others. Tests made on samples consisting of polyvinyl chloride, cellulose acetate and polyamide films cemented to polystyrene films showed that all the combinations had similar stress-elongation behavior. The combination of polystyrene and polyvinyl chloride had the greatest elongation. Elongations at break would be higher than those observed if the inhomogeneities in the materials and the unequal stresses in various parts of the films could be eliminated.

Testing

TESTING CONTAINERS FOR MOISTURE-VAPOR TRANSMISSION. R. W. Lahey. Chem. Eng. News *22*, 636, 638 (Apr. 25, 1944). The information contained in recent publications on testing methods for moisture-vapor transmission is reviewed and discussed.

TESTS AT THE INSTITUTE OF PAPER CHEMISTRY. G. R. Sears, H. A. Schlagenhauf, J. C. Givens and F. R. Yett. Paper Trade J. *118*, 39-40 (Jan. 20, 1944). Twelve materials were tested for water vapor permeability by the GFMVT method, one modification of the GFMVT method, and the IPC method. The agreement between the GFMVT method and the constant rate variation of the GFMVT method is good. The values obtained by the IPC method are generally lower than those for the other two methods. This is particularly the case for the three-ply glassine and the waxed glassine. These discrepancies are important because they are most pronounced for the less permeable samples.

LIGHT SCATTERING IN SOLUTIONS. P. Debye. J. Applied Phys. *15*, 338-42 (Apr. 1944). The fundamentals of light scattering by solutions are presented. Observations of small-angle scattering can be used to determine the number of particles or what is equivalent to their "molecular weight." It is more practical to observe the actual angular distribution of scattering and by comparing this with the distribution to be expected of infinitely small particles, to determine an experimental value for a reduction coefficient which, introduced in the equation developed, will yield a value for the number of independent particles for the observed turbidity.

Synthetic Rubber

DRIFT AND RELAXATION OF RUBBER. M. Mooney, W. E. Wolstenholme and D. S. Villars. J. Applied Phys. *15*, 324-37 (Apr. 1944). Drift tests lasting 8 years have been carried out on rubber blocks in compression at 35° C. Rate of drift, initially high, attains a low constant value in 200 days or less. The initial, rapid drift is termed transient drift; the slower, constant drift is termed steady drift. Drift varies considerably with the type of accelerator in the compound, Ureka giving the lowest drift of the accelerators tested. A new method has been developed for measuring stress relaxation in tension. The stress is measured to 0.1 percent by the resonance frequency of lateral vibrations of the stretched sample. The vibrations are impressed on the sample by a mechanical oscillator in which the source of vibrational energy is a steel wire which is under adjustable tension and is kept in circular vibration by a pair of air jets. Relaxation measurements extending over many months are reported on a soft vulcanized rubber at elongations from 10 to 400 percent at 35 and 70° C. The experimental data can be fitted by a 2-term stress equation of the Tobolsky-Eyring form representing two slip mechanisms, or transient and steady relaxation. Steady relaxation follows an exponential decay law. This means that the residual stress goes to zero at infinite time. Other stress relaxation data are reported for rubber at 150 percent elongation, at temperatures from 35 to 113° C., in air and in vacuum. Air, as compared with vacuum, produces little effect at 35°; but at 70° and higher, the rate of steady relaxation is greatly increased. Thus, oxidation appears to be the major factor in steady relaxation at elevated temperatures. Total transient relaxation is unaccountably increased by vacuum and heat. A modification of the Tobolsky-Eyring equation is developed for steady relaxation. For transient relaxation a new theory is developed which leads to the Tobolsky-Eyring equation, but involves different interpretation of the parameters. In this theory, transient relaxation is attributed to rupture of secondary chemical bonds or crystal forces, followed by longitudinal slippage of chain molecules, with partial or local equalization of tension along the chains. The crystallites then reform, and the rupture and slippage process is repeated. The energy dissipation is attributed primarily to release of local elastic stresses following bond rupture. Transient relaxation is complete when the tension is completely equalized over the total length of each chain between cross links. Neither of the new equations can be distinguished from the Tobolsky-Eyring equation at present.

A NEW EXTRUSION PLASTOMETER. H. A. Schultz and R. C. Bryant. J. Applied Phys. *15*, 360-3 (Apr. 1944). An instrument has been designed to determine whether a given batch of synthetic rubber tread stock can be forced through a plate die to form a satisfactory tire tread. The instrument takes the form of an extrusion plastometer which uses special dies. The factory tubing properties of a batch can be predicted from the appearance of the sample extruded through this die and from the extrusion rate.

PLASTICS DIGEST

This digest includes each month the more important articles of interest to those who make or use plastics. Mail request for periodicals directly to publishers.

General

PLASTICS AND THEIR PLACE IN POST-WAR BUILDING. H. H. Lusty. British Plastics *16,* 55–60, 116–18 (Feb., Mar. 1944). The possibilities for the use of plastics in building construction are discussed. It appears unlikely that plastics will be able to compete with metals for window frames and that transparent plastics will supplant glass in any but a few specialty uses such as curved sections and where wire reinforced plastics may be used to advantage. Plastics appear to have a future for wall and floor tile. Plumbing, plastic tubing, float balls, lavatory cisterns, shower-spray heads and faucet handles appear to be promising uses for plastics. Laminated plastic panels, plywood and laminated timbers will be used more extensively. The plastics now known do not have the requisite strength and low cost to be used for structural parts of buildings.

NEW PLANT FIRST TO PRODUCE ZEIN ON COMMERCIAL SCALE. Chemical Industries *54,* 670–1 (May 1944). A process used to produce zein on a commercial scale is briefly described. The zein is extracted from corn gluten meal with isopropyl alcohol and purified by the selective solvency of hexane and isopropyl alcohol. Zein is used mainly in the protective coating industry as a replacement for shellac, for grease-proof heat-sealing paper coating and for chill sprays for magnesium castings.

METHYLOLUREA ADVANCES RESIN IMPREGNATION OF WOOD. J. F. T. Berliner. Chemical Industries *54,* 680–2 (May, 1944). The process for treating wood with methylolurea and then polymerizing the chemical in situ is described in detail. Data on costs are also given.

METALLIZING PLASTICS. E. E. Halls. Plastics *7,* 235–43, 281–6, 337–48, 400–7, 429–32, 486–95, 507, 549–61; *8,* 4–9, 112–23, 154–65, 204–8 (June, July, Aug., Sept., Oct., Nov., Dec. 1943; Jan., Mar., Apr., May 1944). This series of articles describes the methods of forming metal films on plastics. These films are used for protection and decoration. The article in the June 1943 issue describes the application of a metal powder in a varnish or lacquer medium. The article in the July issue describes the formation of electrically conducting film applied by means of metal powder in varnish or lacquer medium. The articles in the August and September issues describe metal coatings applied by the hot-spray technique. The article in the October issue describes superficial metal layers molded or pressed on material and interior layers pressed in phenolic laminated boards. The article in the November issue describes metal cores molded in rods and tubes. The article in the December issue describes the application of metal films by the hot branding processes. The articles in the December 1943 and January 1944 issues describe the electrodeposition of metal coatings on plastics. The article in the March issue describes the application of metal coatings by electrical sputtering. The article in the April issue describes the application of metal coatings by thermal evaporation in vacuum. The article in the May issue presents some miscellaneous additional information.

DEVELOPMENTS IN THE MANUFACTURE OF STRUCTURAL PRODUCTS FROM HYDROLYZED WOOD. R. M. Boehm. Paper Trade J. *118,* 35–8 (Mar. 30, 1944). A brief description of the Masonite process is given. The products made by this process vary in specific gravity from 0.02 to 1.44. Modifications of the process to produce structural materials for use in making metal-forming dies, panels for ship building, lighting fixtures and lofting boards for ships and aircraft are described. These new products utilize the plastic properties of the by-products obtained when the wood is hydrolized.

PROPERTIES OF WOOD IMPROVED BY CHEMICAL IMPREGNATION. Aero Digest *45,* 104 (May 1, 1944). The treatment of wood with urea and dimethylolurea and the formation of a resin in situ are described. This process improves dimensional stability, machining properties, strength, hardness and general durability of the wood.

PAPER-BASE AND WOOD PLASTICS. A. J. Stamm. Pacific Pulp Paper Ind. *18,* 41–2, 45 (Feb. 1944). The properties of improved resin-impregnated paper-base laminates and hydrolyzed wood molding compounds developed at the Forest Products Laboratory are described.

Materials

WOODFLOUR PRODUCTION. R. S. Aries. Am. Lumberman No. 3282, 213–21 (May 13, 1944). The estimated production of woodflour in this country for 1943 is 60,000 tons. Woodflour for most uses must be 1) light in color, 2) light in weight, 3) fluffy and 4) absorptive. There are three general types of woodflour. Technical woodflour is made from a limited number of species of wood and each species is usually kept separate; this type is used principally as a filler for plastics. Non-technical woodflour is a low-grade type with a wider latitude in fineness, color and resin content than the technical type; this type is used to make wood moldings and in linoleum and fabricated shingles. Granularmetric wood flour is a specialized type which must conform to a specific weight or size with close tolerances; this is an expensive product and is used only for special purposes. The commonest woodflour mesh size is 80; the present production ranges from 50 to 140 mesh. Seventy-five percent of the woodflour produced in the United States is made from white pine; most of the other 25 percent is made from poplar, spruce, hemlock, maple and birch. In normal times 40 percent of the woodflour is used in linoleum, 25 percent in dynamite and a large part of the balance in plastics. Other uses are composition flooring (other than linoleum), wall paper, and simulated wood. A recently developed product is a novel insulating brick. Woodflour can be made by 1) stone mills, 2) double attrition mills, 3) single attrition mills, 4) hammer mills, 5) roller mills and 6) beater mills. The shavings or sawdust is usually dried before it is fed into the grinding mill. Production costs for a plant of 5,000 tons yearly output are given. A discussion of the sawdust and shavings industry is included.

REINFORCED LAMINATES AND PLASTICS HEATER PANELS. British Plastics *16,* 97–102 (Mar. 1944). Two recent developments in laminates in England are described. One of these products is made of a fabric which has 24 high-tensile steel wires and cotton threads to the inch. The fabric is an interlocking weave with the steel wires in both directions. The ultimate tensile strength of this fabric both longitudinally and transversely is more than 24,000 p.s.i. A paper or fabric laminated phenolic plastic which has one layer of this fabric imbedded in it has a specific gravity of 1.65 and a B. S. A. Izod impact strength of 16 foot-pounds. This material has superior dimensional stability characteristics. Reinforced plastics made with this new fabric may also be faced with resin-bonded soft wood veneers to give a stronger, more isotropic, more dimensionally-stable type of plywood which has a tensile strength of 27,000

p.s.i. in both directions; this product is molded of phenolic resin at 160° C. for 20 min. at 500 p.s.i. and cooled under pressure. The above types of materials have been used to build experimental bridges for light weight vehicles, railway cars and aircraft flooring. They are being considered for all types of construction purposes. In the other product, resistance wire is woven in the form of loops with cotton into fabric which is then imbedded in a paper base phenolic laminate. This product is being used as heater panels in hospitals and in ship cabins, and as heating mats in cars, buses and railroad cars. These panels are particularly useful in damp or wet conditions as they are waterproof and shockproof.

PREPARATION AND PROPERTIES OF STARCH ACETATE. L. T. Smith and R. H. Treadway. Chem. Eng. News *22*, 813–17 (May 25, 1944). Conditions of acetylation of potato starch by two methods have been studied: esterification in a mixture of acetic acid and acetic anhydride and acetylation in acetic anhydride of starch preswelled with formic acid. Perchloric and sulfuric acids were found to be superior among a number of catalysts evaluated. The acetylation of starch preswelled with formic acid required approximately 1 hr. at 95° C., as compared with 9 hr. for the first method. Starch acetates having a wide range of viscosity and with different solubility characteristics were made by diversified conditions of preparation. Owing to the short reaction time, acetyl starch prepared by the second method was only slightly degraded. As a result, this method gave esters of higher viscosity. By the first method, air-dry starch gave acetates of higher viscosity than oven-dried starch of nearly zero moisture content. Oven-dried starch was preferred for use with the second method. In dilute solutions of organic solvents, starch acetates prepared by the second method had viscosities of the same order as high-viscosity commercial cellulose acetate.

Molding and fabricating

AIR FORMING METHODS SPEED PLASTICS FABRICATION. Chemical Industries *54*, 850–1 (June 1944). A sheet of methyl methacrylate resin is heated to 250° F. in an oven, laid over the top of a vacuum pot and clamped in place. Vacuum is then applied and the resin is drawn into the form of the pot. When it touches the bottom a contact point is hit which shuts off the vacuum. In case the sheet tends to draw away from the contact point, the vacuum valve is reopened. A variation of this method consists of drawing the sheet into the pot, lowering a form into the bowl and then allowing the sheet of resin to form around the form by releasing the vacuum while the resin is soft.

PROCESS FOR MAKING MOLDS BY ELECTRODEPOSITION. P. Spiro. Plastics *8*, 229–31 (May 1944). A method for making molds by electrodeposition is described. A master is made of plastic and well polished. This is then covered with an electrodeposited nickel alloy about ⅛-in. thick. The metal shell is stripped from the plastic and then backed with mild steel or cast iron to produce the die.

PRODUCTION OF FORMED ARTICLES FROM SOFT PLASTICS. H. Saechtling. Kunststoffe *33*, 291–4 (1943); Chem. Ab. *38*, 3042 (June 20, 1944). The forming of articles from pregelled polyvinyl chloride or from suspensions of polyvinyl chloride in liquid plasticizers is described.

THE WELDING OF THERMOPLASTICS. G. Haim. Plastics *8*, 24–30 (Jan. 1944). The methods used for welding thermoplastics are discussed. Methods of heating include 1) a stream of hot air or hot gas, 2) electrical torches and 3) holding plastic against hot metal plate. Most of the applications described use polyvinyl chloride plastics. It is also possible to weld methyl methacrylate resin, polystyrene, polyisobutylene, polyvinylidene chloride, hard rubber and rubber hydrochloride.

UNITING THERMOPLASTIC RESINS. I. DEVELOPMENT OF THE PROCESS. UNITING IGELIT PCU SHEETS. A. Henning. Kunststoffe *32*, 103–9 (1942). Techniques for uniting Igelit PCU, polyvinyl chloride, sheet and tubing are described in detail. Union in the presence of oxygen produces bonds with high strength. The effects of water, sulfuric acid, hydrochloric acid, nitric acid and sodium hydroxide on the strength of the bonds formed are reported.

Applications

PLASTIC AIRPLANE PARTS STAND TEST OF TIME. Aero Digest *45*, 98, 100, 216, 218 (Apr. 15, 1944). The plastic airplane parts which have stood the test of time and those which are withstanding the competition resulting from the increased supply of aluminum are described. These include transparent enclosures, radio antenna mast, doghouse, turret swivel joint, fuel cavity liner, control pulleys, aileron quadrant, bulkhead doors, bomb-bay, carburetor de-icer tank and flooring.

CAPTURED GERMAN PLASTIC LANTERN. Plastics *8*, 65, 96 (Feb. 1944); British Plastics *16*, 61–2 (Feb. 1944). An acetylene lantern which consists of a body, a generator, and a water tank and burner assembly is described. Except for the glass windows, the water tank and the burner assembly, the lantern is molded of a macerated fabric high-impact phenolic plastic. The plastic on the inside of the dome was blistered and the dome had cracked near one of the hinge holes. The British consider it an unsuitable application of plastics.

PREFABRICATION AND PLYWOOD. British Plastics *16*, 144–7 (Apr. 1944). The use of resin-bonded plywood in the design of prefabricated buildings is described. The results of strength tests on columns and beams of the types described are reported. The columns, beams and floorings are hollow units built from resin-bonded plywood. A thermosetting synthetic resin glue is used throughout in the assembly of the structural members.

THEORY AND PRACTICE OF ELECTRICAL INSULATION. Plastics *8*, 209–13 (May 1944). This article is based on a German publication by H. Heering in Electrotechn. Zeitschrift *63*, 439–42 (1942). Natural and synthetic organic substances for specific electrical insulating purposes are compared.

ARMY PLASTIC FUSELAGE. Automotive and Aviation Ind. *90*, 29, 212 (May 15, 1944). The glass-reinforced plastic fuselage recently built by the Army Air Forces Materiel Command is described. This fuselage is made by the low-pressure laminating process.

Coatings

BEHAVIOR OF RESINS IN CELLULOSE NITRATE LACQUERS. IV. COMPATIBILITY OF RESINS WITH PLASTICIZERS. A. Kraus. Farben-Ztg. *46*, 561–2 (1941). Data are given on the solubility of plasticizers and European synthetic resins in various solvents and on the compatibility of these plasticizers and resins with cellulose nitrate in typical lacquer formulation. The compatibility of the materials does not correlate with their polarity.

DISPERSION RESINS AND THEIR UTILIZATION. W. R. Catlow. Pacific Plastics *2*, 4–6 (May 1944). The properties and advantages of coating materials applied in the dispersed state are described. The best known types are the water emulsions of oil-modified phthalic alkyd resins and oil-reactive ester resins based on acids such as bicycloheptene dicarboxylic. Coatings of this type 1) dry quickly, 2) are improved by baking, 3) are resistant to aging, 4) have low moisture permeability, 5) are resistant to water immersion, 6) are resistant to corrosion by salt spray, 7) are resistant to chalking and fading, and 8) have good durability, especially in primers. Caulking compounds which shrink in one direction may be made from dispersion resins. These dispersed resins may be blended with varnishes for quick-setting low-cost enamels.

U. S. Plastics Patents

Copies of these patents are available from the U. S. Patent Office, Washington, D. C., at 10 cents each

PLASTIC COMPOSITION. S. P. Lovell and H. H. Straw (to Beckwith Manufacturing Co.). U. S. 2,346,136, April 11. A composition of ethyl cellulose plasticized with partially saponified candelilla wax.

SYNTHETIC YARN. R. F. Conaway (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,346,208, April 11. High-tenacity yarns are prepared by dry heating with radiant energy, moisture-free filaments, yarns, threads and ribbons of artificial thermoplastic material which have been heated under tension while maintained at a temperature just below the softening point and allowed to cool while under the same tension.

CELLULOSE DERIVATIVES. B. S. Farquhar (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,346,210, April 11. Cellulose acetate is dry pressed at pressure between 10,000 to 40,000 p.s.i., thus forming tablets which may be ground to desired dimensions.

ADHESIVE TAPE. R. E. Johnson, U. S. 2,346,219, April 11. A tape folded along a longitudinally extending line, the underside of which is coated with an adhesive.

PURGING DEVICE. L. K. Merrill and W. R. Wheeler (to Carbide and Carbon Chemicals Corp.). U. S. 2,346,228, April 11. A composition for purging injection molding machines, comprising a granular mass containing a vinyl resin, plasticizer and a mildly abrasive filler.

WOOD TREATMENT. J. F. T. Berliner (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,346,286, April 11. Moisture-containing wood is chemically seasoned by applying thereto a urea solution, the quantity being increased by using a jellified aqueous urea solution.

CELLULOSE ACETATE. E. Berl and W. G. Berl. U. S. 2,346,350, April 11. A highly acetylated non-fibrous cellulose acetate, originally insoluble in acetone and made soluble by subjecting an acetone suspension, with the fiber structure destroyed, to $-20°C$.

CELLULOSE ESTERS. C. J. Malm and C. L. Crane (to Eastman Kodak Co. U. S. 2,346,498, April 11. Cellulose esters are stabilized by stirring with a mixture of a water-miscible organic solvent and water with which a dough-liquid mass is formed, continuing the stirring while maintaining at a pH of 6 and preventing hydrolysis by adding a neutralizing agent at intervals until constant pH is attained.

LACQUER. V. A. Navikas (to Armstrong Cork Co.). U. S. 2,346,600, April 11. A thermoplastic lacquer, comprising isobutyl methacrylate, *n*-butyl methacrylate, coumarone-indene resin, nitrocellulose, a plasticizer and a solvent, which is baked at 200°F. to a hard film.

COATING. J. B. Brennan and L. Marsh (to J. B. Brennan) U. S. 2,346,658, April 18. Aluminum is protected from corrosion by subjecting it to electrolysis as an anode in an aqueous solution of a potential condensation product of urea and formaldehyde having boric acid and ammonium hydroxide, and carrying out the electrolysis at a voltage sufficient to cause sparking on the aluminum surface.

UREA-FORMALDEHYDE RESIN. L. Smidth. U. S. 2,346,708, April 18. A substantially dried plastic urea-formaldehyde resin is worked between rolls in the presence of a solvent to form a flowable mass, the conditions being such as to advance the cure nearly to completion then adding to a mold wherein the temperature is lowered causing the mass to set.

LIGHT POLARIZER. E. H. Land (to Polaroid Corp.). U. S. 2,346,766, April 18. A light polarizing device comprising a sheet of transparent plastic material in which are suspended a number of oriented fibers containing dichroic material.

OPTICAL DEVICE. J. Mahler (to Polaroid Corp.). U. S. 2,346,774, April 18. A stereoscopic device comprising a pair of sheets of water absorbing material, each defining an image comprising respectively right and left eye images, said sheets being placed with the relief thereon in face-to-face relation, and means providing a hinged connection between sheets, the reliefs being adapted to absorb aqueous solutions of dichroic dyes and to transfer said solutions to a sheet of molecularly oriented polyvinyl alcohol.

POLARIZING BODIES. L. Pollack (to Polaroid Corp.). U. S. 2,346,784, April 18. A centrifugal machine comprising a hollow rotatable drum, means for depositing on the inside a plastic material containing orientable crystals and means for applying a unidirectional electrostatic field.

INTERPOLYMER. C. J. Mighton (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,346,858, April 18. A monomeric vinyl ester of a saturated monocarboxylic acid is interpolymerized with the organic solvent soluble product of the reaction caused by heating a frosting drying oil composition with a member of the class of alpha, beta-ethylenically unsaturated carboxylic acids and esters, primary amides, nitriles and anhydrides thereof.

TEXTILE IMPREGNATION. L. Beer. U. S. 2,347,024, April 18. Textile material is impregnated with an aqueous solution of octa-decyl-oxymethyl-pyridinium chloride and a thermosetting urea- or urea-thiourea-formaldehyde resin.

RESIN. G. F. D'Alelio and J. W. Underwood (to General Electric Co.). U. S. 2,347,032, April 18. An acid curing, thermosetting resin containing a curing agent comprising a diamino-triazinyl-substituted alkyl sulphide.

FILAMENTS. E. Dumont (to Alien Property Custodian). U. S. 2,347,037, April 18. Filaments are prepared by extruding a mass of molten thermoplastic resin through a nozzle which is rotated about its longitudinal axis and which twists the exudate, and then lengthwise cold drawing the twisted exudate by drawing from the nozzle at a speed greater than the rate of extrusion.

POLYSTYRENE. R. F. Hayes (to Monsanto Chemical Co.). U. S. 2,347,103, April 18. A molding composition comprising a mixture of polystyrene and decachloro-diphenyl having a heat-distortion temperature above that of polystyrene.

POLYMERIC SULFIDES. D. D. Coffman (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,347,182, April 25. Polymeric sulfides are prepared by reacting a mixture of a dithiol and a diene hydrocarbon, containing only ethylenic unsaturation, by heating until a viscous to solid polymer is formed.

GLOW SHEET. A. R. Russell (to Burkhardt Co.). U. S. 2,347,285, April 25. A glow sheet comprising a plastic sheet embossed with ink compatible with the sheet material, a layer of fluorescent pigment on said ink, a protective film over the entire sheet composed of a siccative material nonfluorescent under ultraviolet radiation, a second layer comprising a clear ink compatible with the protective

layer, a layer of fluorescent pigment on the second copy layer and a final protective layer of the same characteristics as the former.

CASTING COMPOSITION. J. R. Hiltner (to Rohm and Haas Co.). U. S. 2,347,320, April 25. A mixture of granular polymethyl methacrylate and monomeric methyl methacrylate is poured into a mold and heated under a pressure of 50 to 75 p.s.i. at 75° to 150°C. until the monomer is polymerized, after which the material is cooled under pressure.

RESINS. C. W. Cuno (to Lehon Co.). U. S. 2,347,464, April 25. Thermoplastic material is ground to a fine powder in the presence of solid carbon dioxide and a liquefied gas which liquefies at a temperature below the melting point of solid carbon dioxide.

POLYAMIDE-CELLULOSE MIXTURE. K. Thinius (to Alien Property Custodian). U. S. 2,347,525, April 25. Films, foils and filaments are prepared by mixing a mineral acid solution of a polyamide with an alkaline solution of a cellulosic material.

WELT INSOLE. W. C. Wright. U. S. 2,347,530, April 25. A welt insole comprising an insole blank of flexible upper leather in combination with a sewing rib of synthetic organic plastic such as Koroseal, Vinylite, etc.

FILMS. H. Dreyfus, R. W. Moncrieff and C. W. Sammons (to Celanese Corp. of America). U. S. 2,347,545, April 25. Films, yarns, filaments, etc., are produced from a condensation product of hexamethylendiamine, adipic acid and formic acid.

DENTAL IMPLANT. E. J. Kresse. U. S. 2,347,567, April 25. A material for making surgical implants, comprising a thermoplastic of the methyl methacrylate type having incorporated therein a solid water-soluble germicidal material.

MOLDING. J. H. Goode. U. S. 2,347,600, April 25. A molding press having multiple pressing platens.

ABRASIVE. R. P. Carlton and B. J. Oakes (to Minnesota Mining and Mfg. Co.). U. S. 2,347,662, May 2. A flexible abrasive sheet consisting of a backing sheet to which are bonded abrasive particles by means of a cured film resulting from the mixture of a thermosetting synthetic resin and a solution of a thermoplastic resin which is compatible with the thermosetting resin.

MOLDED MATERIAL. C. D. Levy. U. S. 2,347,697, May 2. A composite article composed of a highly compacted mixture of powdered bagasse, powdered gilsonite and, on at least one outer surface, a preformed sheet of thermoplastic.

POLYISOTHIOUREA. M. Hunt. (to E. I. du Pont de Nemours and Co., Inc.). U.S. 2,347,827, May 2. A linear polymeric isothiourea wherein the isothiourea groups are joined through sulfur and nitrogen by bivalent hydrocarbon and bivalent ether interrupted hydrocarbon radicals.

COPOLYMER. A. L. Rummelsberg (to Hercules Powder Co.). U.S. 2,347,970, May 2. The reaction product of a polymer of an acyclic terpene having three double bonds per molecule and an alpha, beta unsaturated organic acid or acid anhydride.

PREFORMING. G. B. Sayre (to Boonton Molding Co.). U.S. 2,347,971, May 2. Pills are prepared from thermosetting molding material in powder form by means of pressing in a pill cavity.

CELLULOSE ACETATE. D. L. Gibson and W. M. Shoemaker (to National Vulcanized Fibre Co.). U.S. 2,348,001, May 2. Cellulose material is acetylated by continuously advancing a web through a bath of acetic acid, a bath containing an acetylating agent, and a washing bath.

VINYL CHLORIDE COPOLYMERS. W. Scott and R. B. Seymour (to Wingfoot Corp.). U.S. 2,348,154, May 2. Copolymers of vinyl chloride and vinylidene chloride are formed by polymerizing at a temperature of 20° to 80° C. in an aqueous emulsion containing an oxidizing catalyst.

ADHESIVE PAPER. B. L. Kline (to Western Union Telegraph Co.). U.S. 2,348,220. May 9. An adhesive paper having on one surface a thin dry moistenable film consisting of polyvinyl alcohol.

CATALYST. W. C. Dearing (to Libbey-Owens-Ford Glass Co.). U. S. 2,348,244, May 9. An adhesive having delayed hardening properties comprising a composition of water-soluble urea-formaldehyde resin, a substance such as a magnesium or zinc oxide or hydroxide, and an ammonium salt of a strong acid.

TIRE COVER. H. L. Hollis, U.S. 2,348,256, May 9. A tire cover having a fabric body and a flexible coating containing the reaction product of resorcinol paranitroaniline and formaldehyde.

PLYWOOD TUBING. P. R. Goldman (to Plymold Corp.). U.S. 2,348,291, May 9. Tubing is made by winding wood veneers coated with synthetic resin adhesive, sealing the ends of the tube, introducing gas pressure inside the tube, and maintaining the pressure for a part of the setting period of the resin.

CELLULOSE DERIVATIVES. H. C. Olpin, S. A. Gibson and J. E. Jones (to Celanese Corp. of America). U.S. 2,348,305, May 9. Cellulose derivatives having affinity for acid dyestuffs are prepared by pretreating cotton linters with formic acid, esterifying with a mixture of acetic anhydride, acetic acid, monochloracetic acid, and sulfuric acid, ripening and treating with pyridine.

ADHESIVE. E. Beck (to Alien Property Custodian). U.S. 2,348,447, May 9. A solution of polymeric vinyl isobutyl ether in benzine and acetone.

INSULATION. W. E. Gordon (to E. I. du Pont de Nemours and Co., Inc.). U.S. 2,348,536, May 9. An electrical conductor is insulated by coating with a synthetic linear polyamide which is then cold drawn.

TERPENE RESIN. E. Ott (to Hercules Powder Co.). U. S. 2,348,565, May 9. The copolymerization product of a terpene and an alicyclic hydrocarbon containing a conjugated system of double bonds having 5 to 8 carbon atoms both of which are dissolved in an inert solvent in the presence of a catalyst and subjected to polymerization temperature.

WELT INSOLE. W. C. Wright. U. S. 2,348,583, May 9. An improved method of making a welt insole having an unchanneled insole blank and an adhesively secured sewing rib of synthetic plastic mounted upon a textile base.

SKINNING DIE. J. Bailey (to Plax Corp.). U. S. 2,348,591, May 9. A thermoplastic skinning die comprising a number of die plates having openings therein providing a succession of cutting edges, said openings being so formed and located as to provide a tapered main die opening, means for holding said die plates in spaced relation and means for heating said plates.

TRIM. C. E. Slaughter (to Extruded Plastics, Inc.). U. S. 2,348,658, May 9. A wallboard trim comprising an extruded continuous thermoplastic resin strip.

SHEET MATERIAL. W. R. Collings and T. A. Kauppi (to Dow Chemical Co.). U. S. 2,348,672, May 9. Opaque sheet material containing ethyl cellulose, a pigment and a plasticizer.

POLYMERIZATION. R. D. Freeman (to Dow Chemical Co.). U. S. 2,348,677, May 9. A mold for preparation of resinous objects by the polymerization of a resin-forming liquid comprising a metal mold cavity, the surfaces of which are coated with a film of cellulose glycolic acid or salts thereof.

HOLLOW WARE. V. E. Hofman (to Owens-Illinois Glass Co.). U. S. 2,348,738, May 16. A hollow preform of thermoplastic molding material is expanded within a heated mold by pneumatic pressure and cooled with liquid on the inner surface.

POLYAMIDES. W. R. Peterson (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,348,751, May 16. A solid synthetic

linear polyamide is depolymerized to a liquid by heating in the presence of water, the water is removed, and the residue is repolymerized.

PLASTIC. J. D. Ryan (to G. G. Ryan). U. S. 2,348,756, May 16. An elastic wax-like plastic composition comprising high molecular weight fatty acid or wax, a solid synthetic resin soluble therein and a plasticizer for the resin.

PROTEIN PLASTIC. O. C. H. Sturken (50 percent to Harriet Sturken and 50 percent to Sidney L. Reich). U. S. 2,348,761, May 16. A molded protein article is hardened by immersing in a bath of formaldehyde and kieselguhr.

VINYLIDENE CHLORIDE. R. M. Wiley (to Dow Chemical Co.). U. S. 2,348,772, May 16. Strong flexible articles are prepared from vinylidene chloride polymer and crystalline copolymers thereof, by heating the crystalline polymer to a temperature between its softening and decomposition points, shaping the softened polymer, supercooling the shaped body and stretching at least a portion of the shaped body to effect permanent deformation.

LAMINATING FABRIC. J. E. Bludworth (to Celanese Corp. of America). U. S. 2,348,781. May 16. A laminating fabric is prepared by applying a plasticizer to a fabric containing non-plastic and thermoplastic cellulosic fibers and causing migration of part of the plasticizer from the non-plastic to the plastic fibers by aging at an elevated temperature at a relative humidity of 70 to 90 percent.

ETHYL CELLULOSE. R. R. Bradshaw (to Dow Chemical Co.). U. S. 2,-349,134, May 16. A molding lubricant for use with ethyl cellulose plastics consisting of paraffin wax and a blending agent comprising a paraffin soluble resin and 12-hydroxy stearin.

VINYL POLYMERS. E. C. Britton and W. J. LeFevre (to Dow Chemical Co.). U. S. 2,349,136, May 16. Vinyl aromatic compounds are polymerized in the presence of mesityl oxide to give a low molecular weight vinyl polymer.

PLASTIC ARTICLES. W. H. Kopitke (to Plax Corp.). U. S. 2,349,176-7-8. May 16. Machinery for forming extruded and hollow blown articles from plastic materials.

PLASTIC MATERIAL. O. M. Reiff and O. P. Kozacik (to Socony-Vacuum Oil Co.). U. S. 2,349,198, May 16. Styrene is polymerized in the presence of a substance formed by alkylating phenol with chlorinated petroleum wax in the presence of a Friedel-Crafts catalyst.

COPOLYMER. W. N. Traylor (to Hercules Powder Co.). U. S. 2,349,210, May 16. A terpene resinous copolymer of pinene and styrene is refined by dissolving in a solvent and mixing with sodium acid sulfate and zinc in the presence of a small amount of water.

COATING MACHINE. H. A. Evans (to Coreve Corp.). U. S. 2,349,256, May 23. A machine for continuously permeably affixing plastic material to sheets of material to be coated.

DYE. J. G. Kern (to Allied Chemical and Dye Corp.). U. S. 2,349,282, May 23. Coloring agent for cellulose derivatives.

NYLON. D. L. Loughborough (to B. F. Goodrich Co.). U. S. 2,349,290, May 23. The adhesion of nylon yarn to rubber is improved by treating the yarn with a nylon solvent, immersing in an aqueous dispersion of rubber and drying under tension.

PLASTICIZER. B. Anderson, E. Grenquist and R. H. Ball (to Carborundum Co.). U. S. 2,349,365, May 23. A flexible abrasive disk comprising a backing of reinforced heat hardened phenolic resin and a layer of cloth to which is bonded a layer of abrasive grains by means of a layer of phenolic resin.

VINYL RESIN. S. D. Douglas (to Carbide and Carbon Chemicals Corp.). U. S. 2,349,412, May 23. An electrical conductor is insulated with a copolymer of a vinyl halide and a vinyl ester combined with 15 to 60 percent plasticizer.

VINYL RESIN. W. F. Hemperly (to Union Carbide and Carbon Corp.). U. S. 2,349,413, May 23. An insulating composition comprising polyvinyl chloride, plasticized with di (2-ethyl-hexyl) phthalate.

PLASTIC ARTICLE. J. P. Ferrer and S. D. Douglas (to Carbide and Carbon Chemicals Corp.). U. S. 2,349,414, May 23. Vinyl chloride acetate copolymer plasticized with 22 to 55 percent of plasticizer is prepared in sheet form.

ADHESIVE. G. Mack (to Advance Solvents and Chemical Corp.). U. S. 2,349,508, May 23. A pressure sensitive adhesive comprising polyisobutylene, a thermoplastic resin, a plasticizer and, as a stabilizer, a liquid fatty acid mono ester.

COATING. C. F. Cummins (to Dow Chemical Co.). U. S. 2,349,571, May 23. A bronzing lacquer comprising ethyl cellulose, coumarone indene resin, a plasticizer and a leafing metal powder pigment.

RESIN. B. C. Pratt (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,349,-756, May 23. A hydrocarbon diisocyanate is reacted with a resinous condensation product of formaldehyde and a monomeric organic compound to form a resin.

RESINS. O. M. Reiff and J. D. Zech (to Socony-Vacuum Oil Co.). U. S. 2,-349,759, May 23. Chlorinated petroleum wax is heated with phenol or an aromatic ether in the presence of a Friedel-Crafts catalyst and the product is then heated with an olefin, having conjugated double bonds, in the presence of a Friedel-Crafts catalyst.

RESIN. F. Strain (to Pittsburgh Plate Glass Co.). U. S. 2,349,768, May 23. A polyhydric alcohol polyester of methacrylic acid is partially polymerized, the residual monomer is separated, and the fusible polymer is heated until the infusible state is attained.

CELLULOSE ETHER. L. H. Bock and A. L. Houk (to Rohm and Haas Co.). U. S. 2,349,797, May 30. A water-insoluble alkali-soluble carboxyethyl cellulose ether is prepared by mixing cellulose with a strongly basic solution containing acrylonitrile.

MOLD. M. Bean. U. S. 2,349,806, May 30. A mold for plaster, etc., composed of plasticized vinyl chloride resin.

MINERAL WOOL. V. E. Meharg (to Bakelite Corp.). U. S. 2,349,909, May 30. Smooth surfaced non-cellular fibers of glass wool are coated with a watery alkaline phenolic resin solution, the mass is dehydrated, leaving a bat of cohering fibers.

MOLDED ARTICLE. F. H. Mackenzie (to Alexander Smith and Sons Carpet Co.). U. S. 2,349,975, May 30. A reinforcement for molded plastic articles comprising a pile fabric.

COMB. L. Mazzoni (to Alien Property Custodian). U. S. 2,349,977, May 30. A molding device for the manufacture of a comb from plastic materials.

POLYMERS. O. Moldenhauer and H. Bock (to Alien Property Custodian). U. S. 2,349,979, May 30. A plastic condensation or polymerization product is produced by refluxing hexadecane dicarboxylic acid with hydrazine hydrate for 10 hours and finally heating at 200 to 300° C. for 3 hours.

COATING. W. E. Gloor (to Hercules Powder Co.). U. S. 2,350,161, May 30. An aqueous coating comprising a solution of a cellulose ether and an alkali metal silicate.

VINYL RESIN. R. W. Staley (to General Electric Co.). U. S. 2,350,199, May 30. A composition containing the product of conjoint polymerization of a mixture of vinyl chloride and an acrylic ester and a heat and light stabilizer.

CELLULOSE TRIACETATE. C. Bogin (to Commercial Solvents Corp.). U. S. 2,350,300, May 30. Cellulose triacetate is dissolved in a monochloro mononitro alkane and a lower aliphatic monohydric alcohol.

BOOKS AND BOOKLETS

Write directly to the publishers for these booklets. Unless otherwise specified, they will be mailed without charge to executives who request them on business stationery. Other books will be sent post-paid at the publishers' advertised price.

Synthetic Resins and Allied Plastics, 2nd Edition

Edited by R. S. Morrell

Oxford University Press, 114 Fifth Ave., New York, 1943

Price $12.00 — 580 Pages

The first edition of this book appeared in 1937 under the joint authorship of R. P. L. Britton, T. H. Barry, H. M. Langton and R. S. Morrell. These men have been assisted by the well known authorities — J. R. Alexander, E. A. Bevan, E. G. Couzens, R. Hill, H. S. Lilley, C. A. Redfarn and V. E. Yarsley — in the preparation of this revised and enlarged edition. The materials are covered in 13 chapters, problems of resinification in 2 chapters, and methods of identification and testing of plastics in another 2 chapters. Extensive subject and author indexes are appended to this important contribution to the literature on plastics. G.M.K.

High Polymers

Published by the New York Academy of Sciences, Central Park West at 79th St., New York, 1943

Price $2.00 — 181 pages

This publication is composed of a series of papers presented at a conference held by the Section of Physics and Chemistry of the New York Academy of Sciences. In his introduction to the conference, R. M. Fuoss notes that the academic worker is not happy until he knows (or at least, thinks he knows) why compounds behave as they do. The eight papers comprising this symposium present a review of the current status of our knowledge of the kinetics and structure and correlations between structures and properties of high polymers. G.M.K.

Materials and Processes

by J. F. Young

Published by John Wiley & Sons, Inc., New York, 1944

Price $5.00 — 628 pages

The material for this book has been gathered from many sources including lectures conducted in the advanced engineering program of the General Electric Co. It presents clearly a broad study of the materials and processes employed by the design engineer. Excellent as a reference book, it is organized in such a manner that it can be converted easily to textbook use.

The author has successfully bridged the gap between purely technical problems of the metallurgists and more solid and concrete problems as to the actual operation of the equipment used in producing these materials. F.B.S.

★ "THE ABC OF LUMINESCENCE," released by New Jersey Zinc Co., New York, N. Y., explains the principles of luminescence and discusses the practical application of these principles in the form of activated fluorescent and phosphorescent pigments, and a glossary of luminescent terms is included.

★ A BOOKLET ON "AMINES," RECENTLY published by Carbide and Carbon Chemicals Corp., New York, N. Y., condenses information on 25 members of this group of organic chemicals, available in commercial quantities. Names, formulae, physical and chemical properties, specifications, container and shipping data, applications and uses of each chemical of the family are contained in the first part of the book. The remaining portion of the work is given over to graphical data.

★ INFORMATION ON THE STERling Model "E" air-driven speed-bloc sander and 1000 portable electric sander is now available in two folders recently released by Sterling Tool Products Co., Chicago, Ill. The Model "E" sander uses standard abrasives, sands curved surfaces and may be used wet or dry. The 1000 portable electric sander, which also uses standard abrasive sheets, is built to produce powerful orbital motion.

★ THE CELLULOSE PRODUCTS Department of Hercules Powder Co., Wilmington, Del., has issued a technical booklet describing a plasticizer and a resin which they have developed for use in fireproof, waterproof and weatherproof coatings for fabrics. Clorafin 42, which emulsifies readily, is a light amber, viscous, non-flammable material, shown by tests to be a good plasticizer for some of the vinyl resins. Clorafin 70, a pale straw-colored, hard and brittle resin, has even greater flame-extinguishing characteristics.

★ "DESIGN AND FABRICATION of Laminated and Molded Phenolic Plastics and Vulcanized Fibre Parts," released by Continental-Diamond Fibre Co., Newark 28, Del., is a reprint of the articles: "Fabricating Laminated Plastics and Vulcanized Fibre," from the 1943 PLASTICS CATALOG, and "Design Fundamentals for Phenolics," from the December 1942 issue of MODERN PLASTICS.

★ "BEAUTIFUL WOOD FOR BEAUtiful Homes—with Weldwood," a colorful brochure published by the Mengel Co., Louisville, Ky., presents the present and postwar possibilities of this material. It may be used for decorative panelling or as a durable surface for wallpaper or paint. A postwar development of outstanding merit will be stainless steel tops for sinks and counters formed by the gluing of thin, stainless steel to Weldwood plywood. The booklet is elaborately illustrated with photographs of the material in use.

★ TINIUS OLSEN TESTING MAchine Co., Philadelphia, Pa., describes in detail its complete line of Olsen Brinell hardness testing machines in a new 28-page catalog. Included in the testing equipment that is illustrated and described are three types of the motor-driven machine, Baby Brinell testers and other items produced by this company. Tables of Brinell hardness numbers, specifications, parts and attachments, and maintenance and operational data help to complete the information on these units.

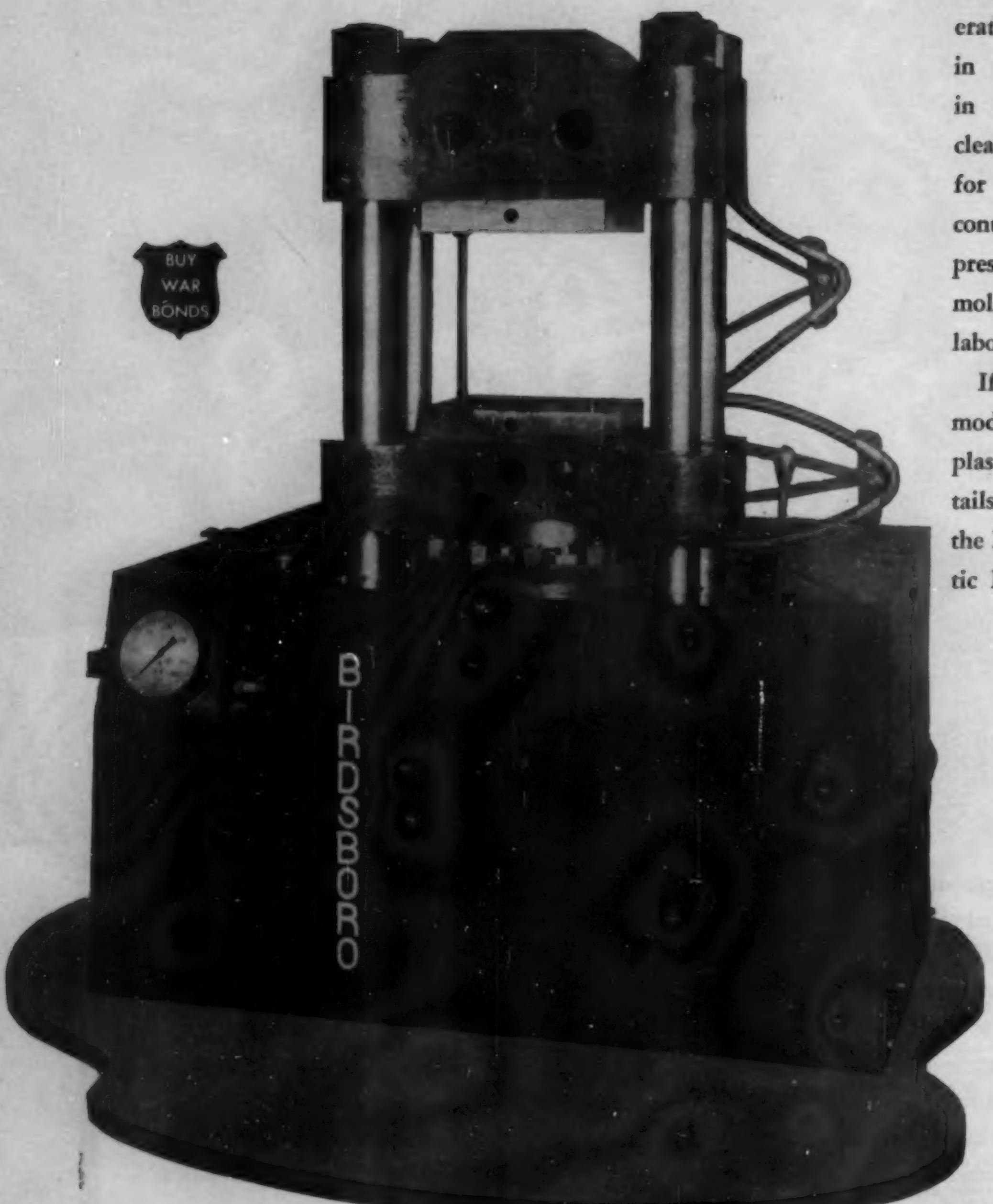
★ ROTARY FILE CO., STRATford, Conn., has published an illustrated catalog featuring their full line of standard shapes in hand-cut rotary files and listing a number of special designs. All varieties of tooth cuts and a wide range of ingenious file shapes are shown, together with tables of specifications for each variety.

★ AN 8-PAGE CATALOG, ILLUStrating and describing engine lathes, toolroom lathes and precision turret lathes for practically all types of production, toolroom and maintenance work, has been released by South Bend Lathe Works, South Bend, Ind. Information concerning capacities, speeds, feeds and dimensions is tabulated for each size and model of lathe, and attachments and accessories available are listed.

★ A NEW USERS' GUIDE ON self-tapping screws is offered by Parker-Kalon Corp., New York, N. Y. It includes a selector chart giving the type of screw to use in various materials, tables showing recommended hole sizes, stock sizes, and data on use of screws under different conditions.

Better Molding Control with

BIRDSBORO'S NEW Hydraulic Plastic Press



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A plastic molding job should be engineered completely to meet the customer's needs—*as Amos does it*. . . . The part or product should be designed for practical utility—for functional use—for dependable accuracy and efficiency—for appearance desired—*as Amos does a job.*

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MOLDED PLASTICS...

Custom Molders of Parts and Products by the Injection Process

Amos does a really complete job for you—uses the right materials in the right places—the right plastics in combination with metal inserts if required. Everything is worked out on the drawing boards—a model is made for approval—dies and fixtures are built for production—all in our own shops. Every detail is checked carefully for size and fit and uniform quality of finished production.

You'll appreciate our engineering service and our complete facilities for doing your job right—whether you need plastic parts for household appliances—cases for clocks or cameras—special handles for tools or machines—a bathroom fixture—or anything else that's a practical plastic job. Write us your needs.

AMOS MOLDED PLASTICS, EDINBURGH, INDIANA

Division of Amos-Thompson Corporation

TULOX Plastic Tubing
REG. U. S. PAT. OFF

in intricate shapes

to help shape victory—to help shape postwar product plans

We now manufacture these special shapes of TULOX tubing to order only. But they have suggested so many postwar end-uses, that we are receiving many inquiries from many unassociated industries.

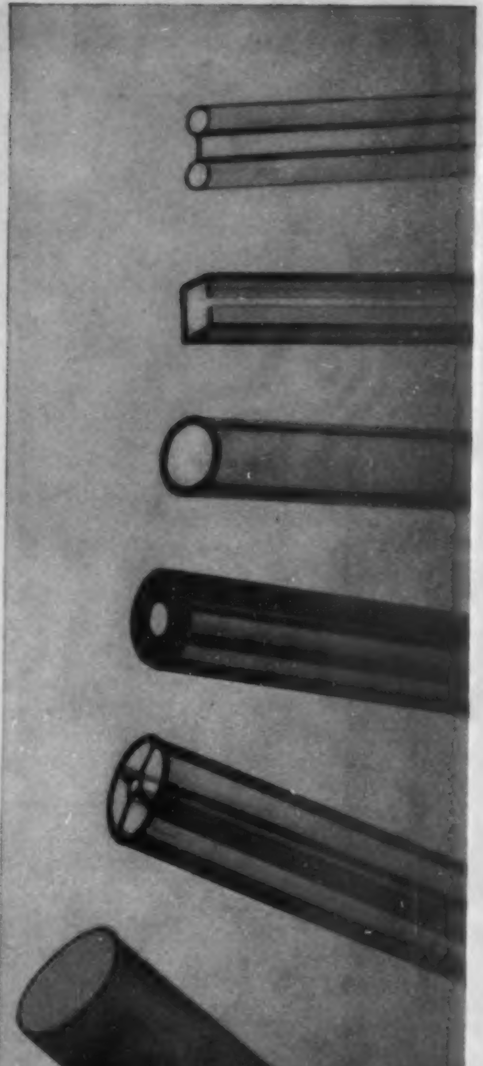
We know TULOX is practically strain-free. We know we can extrude TULOX in micromatic diameters and in theoretically endless lengths. We know we can utilize the important commercial resins in our exclusive TULOX process. We know TULOX is continually solving problems for all types of industry.

We do *NOT* know if TULOX is for you.

But we also know that, if consulted, we will approach your problem with an open mind, an unusually valuable experience, and an excellent and proven product.

May we be of help to you?

A full range of sizes of TULOX TT tubing made from cellulose acetate butyrate is available from warehouse stock.



Research continues at all times, and we are glad to give our customers the benefit of our laboratory and manufacturing experience

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If you combine metal with plastics, remember that The Chicago Screw Company is the foremost producer of quality Brass and Steel Screw Machine Products for more than 72 years.
Our engineering ability and modern production facilities are versatile enough to handle any of your screw machine problems, including all secondary operations, regardless of size, shape or form, and in unlimited quantities.
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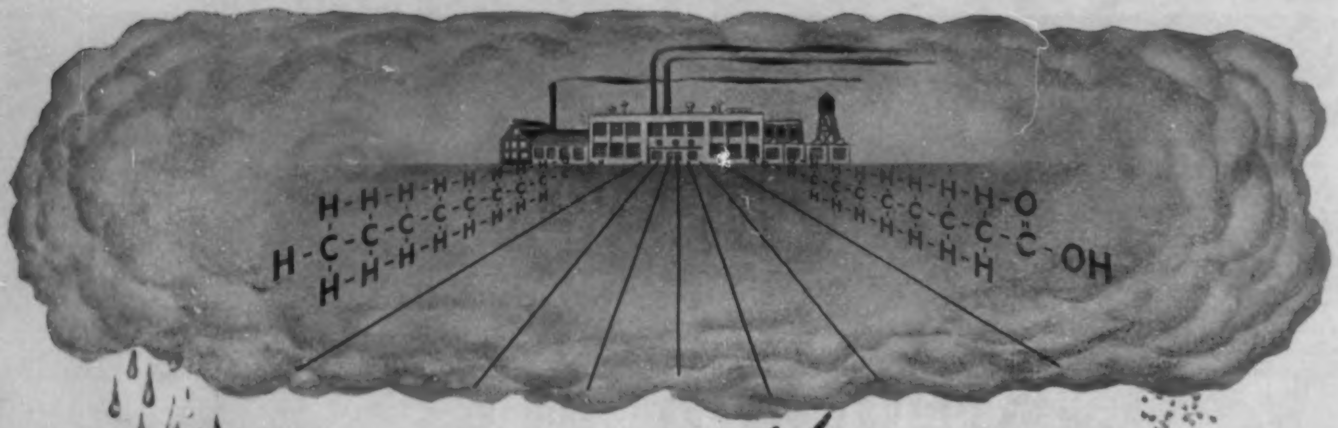
MOLDER'S PRAYER

We are not a beautiful girl and so we don't pray for a handsome knight in armor on a white steed, if that is what beautiful girls still pray for. Perhaps they would prefer a sergeant in a jeep.

Our nightly request runs something like this: "Please give us all of the phenol and all ureas and all the other plastics that we need to fill the orders of our customers. Let them be uniform. Make our molds of strongest steel, with never a scratch or broken pin. Allow our customers to tell us what the pieces are for so that we may design them, mold them, and finish them intelligently.

"Send us plenty of labor and let there be no absentees. Make our presses strong and let them never break down. Mold us no rejects and lead us not into temptation. Let us make an honest profit and send the blessing of sound sleep to us and our customers. And may our customers be charitable of all of our short-comings. Amen."

Join the meeting, brethren.



How an idea took shape

Dreams of the research chemist are not just daydreams, because out of them come new ideas . . . products and methods, too.

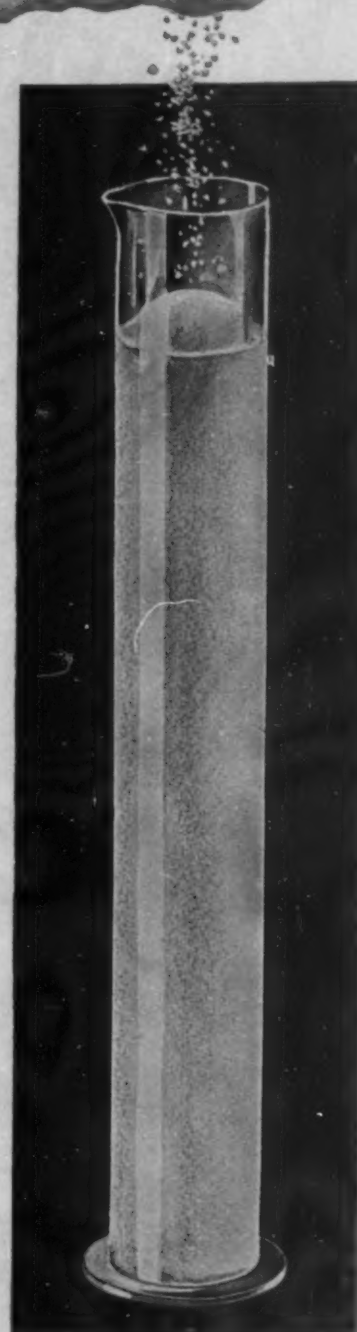
Such a dream was the one of producing shorter-chain-length fatty acids, substances the like of which were *not* found in nature . . . and doing it on a commercially practical basis.

Emery's chemists and engineers have accomplished this, and the new plant of their design will soon be producing two commercially-new aliphatic acids.

One of these is a mixture of monobasic acids, in which pelargonic acid predominates. Its esters are, in general, more compatible with synthetic resins than esters of higher molecular weight acids. This suggests their use as plasticizers.

The other is azelaic acid, a dibasic acid, which reacts with monohydric alcohols to form relatively high boiling esters. It combines with glycerine and other polyhydric alcohols to form *soft* alkyd resins.

Thus, new vistas are opened up for the manufacture of new plastics. If you would like to examine these acids and esters in your own Research Laboratory, just let us know. In the near tomorrow, we will produce them on a large scale to supply you with new raw materials for better plastics where stability and flexibility are of primal importance.



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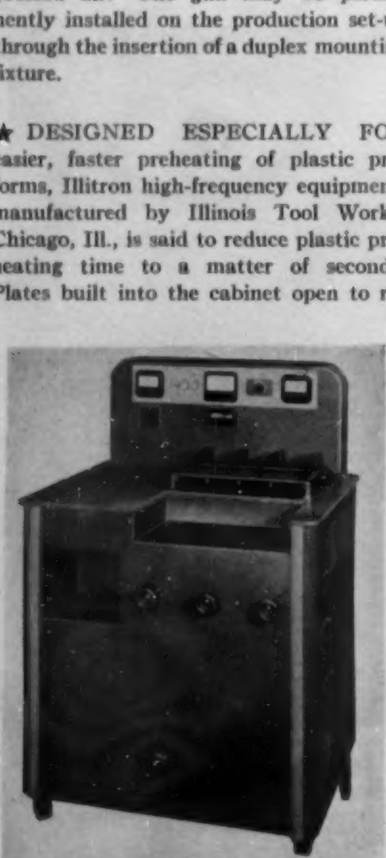
NEW MACHINERY AND EQUIPMENT

★ A NEW TOOL FOR QUICK HEATING—Model LRJ-3 near infrared unit—is announced by Fostoria Pressed Steel Corp., Fostoria, Ohio. Designed to develop relatively high temperatures in from seconds to a few minutes, this hand-model is intended as an efficient means of accomplishing many tasks where quick, easily controlled heating is necessary.

★ METCO TYPE 3E METALLIZING gun is manufactured by Metallizing Engineering Co., Inc., Long Island City, N. Y., and specially engineered for the high-speed production spraying of low melting point metals such as zinc, tin, lead, solder, babbitt, cadmium or fine gage copper and copper alloys. A patented controlled power unit is used to maintain the obtainable speeds. The unit is equipped with a universal gas head, which allows the tool to be operated on any commercial gas—in conjunction with oxygen and compressed air. The gun may be permanently installed on the production set-up through the insertion of a duplex mounting fixture.

★ DESIGNED ESPECIALLY FOR easier, faster preheating of plastic preforms, Illitron high-frequency equipment, manufactured by Illinois Tool Works, Chicago, Ill., is said to reduce plastic preheating time to a matter of seconds. Plates built into the cabinet open to re-



ceive the preforms and close for heating. Close temperature control can be maintained by a meter which indicates the amount of heat generated per second, and by an automatic timer which cuts off the heat after a predetermined time. Adjustment can be made for change in types of preforms, and the power level controlled from zero to the maximum rated capacity of the unit.

★ "SHAPE MASTER," A NEW shape-turning lathe introduced by Monarch Machine Tool Co., Sidney, Ohio, is said to be capable of doing the most intricate shaping and forming on work up to 16 in. in diameter. The unit consists of three elements: one controlling the shape cut, another regulating the rate of repetition, and a third controlling the contour. A piece of work, such as an oval dish mold with as many as 16 flutes, can be completely machined in only $2\frac{1}{2}$ hr. And the original mold can be duplicated exactly as many times as is necessary.

★ TO FINISH THE BAKING OF small items, Koch Industrial Equipment, Evansville, Ind., have designed a special drawer type oven which is operated by heated air, circulated on the down-draft principle. The drawers are constructed of expanded metal and close against asbestos gaskets which help to insure free circulation of the air and eliminate heat losses. The ovens are said to attain temperatures up to 500° F., under fully automatic control, and they may be connected to a system of exhaust piping if conditions require it.

★ A HIGH-SPEED STEEL DRILL with a high helix angle and very wide flutes has been developed for plastic drilling by Ace Drill Corp., Detroit, Mich. The point of the drill is dubbed on the cutting edge, producing a negative rake and resulting in better chip action. The helix angle on fast spiral drills, $^{9}/_{32}$ in. diameter and smaller, is 40 degrees. On drills over $^{9}/_{32}$ to $^{1}/_{2}$ in. diameter, inclusive, the angle is 45 degrees. Hardening is fully developed over the entire cross-section of the drill, and maximum cutting ability and red hardness, essential when drilling plastics, is guaranteed.

★ MODEL SER MACHINE, MANUfactured by Charles E. Francis Co., Rushville, Ind., is a single roll spreader for applying glue to edges of lumber, boxes, etc. The crotch formed by the coating and doctor rolls is used for holding the glue, thus keeping the roll well supplied and avoiding waste. Seal plates at each end of the rolls prevent glue from running out of the crotch. The machine is driven with $^{1}/_{4}$-hp., 110-volt motor, and speed can be changed to order. Other adhesives and coatings can also be used in these spreaders. If necessary a pan can be added to hold extra fluid.

★ A NEW AMERICAN SPEED-JACK, manufactured by the American Pulley Co., Philadelphia, Pa., features simplified remote control and universal mounting. By reason of a compact flexible shaft, the unit may be mounted on any section of a machine, thus broadening the field for speed-jack applications. Plastic flanges, steel-faced for long service, are understood to make the jack lighter and provide accurate balance and smooth, quiet vibration-free operation.

★ SIMPLICITY, FAST OPERATION, safety and dependability in service are some of the advantages claimed for Air-

tronics preheaters, recently introduced by Airtronics Mfg. Co., Los Angeles, Calif. Power is controlled by dials, heating is adjusted with ease, and timing is automatic. The units are provided with effective devices to protect the operator and the equipment. Each part of the model is said to be capable of handling substantially higher loads than normally imposed upon it—to insure dependable service under severe conditions.

★ THE INDUSTRIAL MACHINERY Co., Bloomfield, N. J., is producing a one-gallon autoclave which is said to combine in its design construction equipment all of the functions and usual features of large high-pressure autoclaves, sulphonators, nitrators, chlorinators, kettles and similar equipment. The autoclave consists of a pot or body, which can be fitted with either a one-piece pressure jacket or steel direct-gas firing stand, a stirrer and a cover. The pressure jacket contains a threaded connection for the installation of a thermometer if necessary.

WASHINGTON ROUND-UP

R. L. VAN BOSKIRK, Washington Editor

Machinery Order L-159 revoked

WPB revamped the plastics machinery situation on June 23 by revoking Order L-159, thereby relinquishing control of used machines, molds and fixtures. At the same time, delivery of new machines was placed on a scheduling rather than a priority basis by amending Table 15 of General Scheduling Order M-293 to include all *new* plastics machinery: specifically, compression presses (automatic, hydraulic, mechanical), extruders, injection presses, laminaters and laminating process (laboratory-type) and preformers. The only machinery items now controlled are completed, whole machines.

Order M-293 places all sorts of things on a production schedule drawn up by WPB. Chemicals machines (including plastics) are now on Table 15 of this order and classified as "Y" products. Class "Y" products are those components and parts over which WPB exercises purchase control. Persons desiring to purchase such equipment are required to obtain specific authorization from WPB at Washington, D. C., on Form WPB 1319 in order to place their orders.

Allocations of new machines will be on a quarterly basis. No applications for injection machines will be processed before Oct. 1 except in case of the most urgent military necessity. The reason is that there are far more injection machines already on the manufacturer's books than can be delivered in the near future.

Under the old method, all authorized plastics machinery carried the same rating. Consequently, it was difficult to push the delivery of machines for a very important end use. Under the new system, WPB will tell the manufacturer which machines to deliver first, and ratings have no effect on a frozen schedule.

All operators should obtain a copy of M-293 and study it carefully. Particular attention is called to Paragraph 5-d-(1)-(2) which specifically states among other things that no person shall place the purchase order with the manufacturer and no manufacturer shall accept the purchase order for any Class "Y" product unless the purchase order is accompanied by specific authorization of WPB obtained on Form WPB 1319, Table 15.

M-293 further states in Paragraph (g) that WPB may, notwithstanding any other order, preference rating, directive, rule or regulation (except Priorities Regulation 18) of WPB, or of any other government agency:

1. Revoke any authorization;
2. Direct the return or cancellation of any purchase order;
3. Direct changes in the shipping schedule;
4. Cancel purchase orders with one manufacturer and direct them to another;
5. Take such other action as may be necessary for the placing or shipment of M-293 products.

OPA amends price order

Amendment No. 1 to the Plastics Products Pricing Order MPR-523, June 23, 1944, is intended to clarify certain phases of the original order. Probably the most important aspect of the amendment is OPA's effort to limit coverage of the order to strictly plastics processors. The original order brought in many manufacturers who were in no sense plastics operators but who made and used plastic parts in their finished item. It was never intended to bring such companies under this order—they all operated under other regulations.

The test as to whether or not a given firm is outside control of Order MPR-523 is that firm's customary practice of issuing price lists, catalogs or advertising which represent that company as being the manufacturer of a definite item. Thus, a firm known as the manufacturer of vacuum sweepers, fountain pens, telephones, etc., is definitely exempt from control under MPR-523. On the other hand, a manufacturer of a solid plastic product such as combs will come under MPR-523 even though he may be advertising as the Blank Comb Company. Reason: a fountain pen is an assembled item—a comb is not.

Sunglass frames are an example of a partial plastics product that may or may not be included in this order. If a given company manufactures plastic optical or sunglass frames and sells them to an assembler, he is under terms of MPR-523. But if the company manufactures, assembles and markets these items representing itself as a manufacturer of sunglasses, the firm does *not* come under MPR-523. Decision as to the price order governing a given item may often be determined on the basis of the ownership of the mold. Say that company A is an optical manufacturer, and B is a plastics molder who makes optical frames for company A, who owns the mold. Obviously only B, the molder, would come under MPR-523. But if B owns the mold, assembles and markets the sunglasses, yet is still known primarily as a plastics manufacturer, he is governed by MPR-523. On the other hand, if B owns the mold, assembles and markets the sunglasses but sells them to the trade as a manufacturer of sunglasses, the product will *not* be under MPR-523.

Some cases are going to be laid directly on the OPA doorstep, and each case will be handled according to its own peculiar situation. Probably not more than 30 or 40 companies will have any cause to question their particular status, and OPA officials doubtless think it is easier to take care of them individually than to continue operating under the old order which confused many manufacturers who made and used plastic parts in finished products.

In so far as price of his product is concerned, the new amendment makes little difference to a manufacturer. If his product is not under MPR-523, it is already priced under MPR-188 (consumer durable goods) or some other specific order.

Specific exemptions—Several items have been automatically exempted from MPR-523 because they are definitely covered by other regulations and not customarily produced by plastics molders and laminators. The exempted items are: combined fabrics; cements and adhesives; laminated sheets, rods and tubes prior to fabrication (controlled under MPR-519 for thermosetting laminates); phonograph records; screen cloth; wearing apparel and sheetings; electrical wire and cable.

Saran tubing and piping are also excluded from this order because they are controlled by a building materials order. However, tubing made from other types of plastics is included under control of MPR-523.

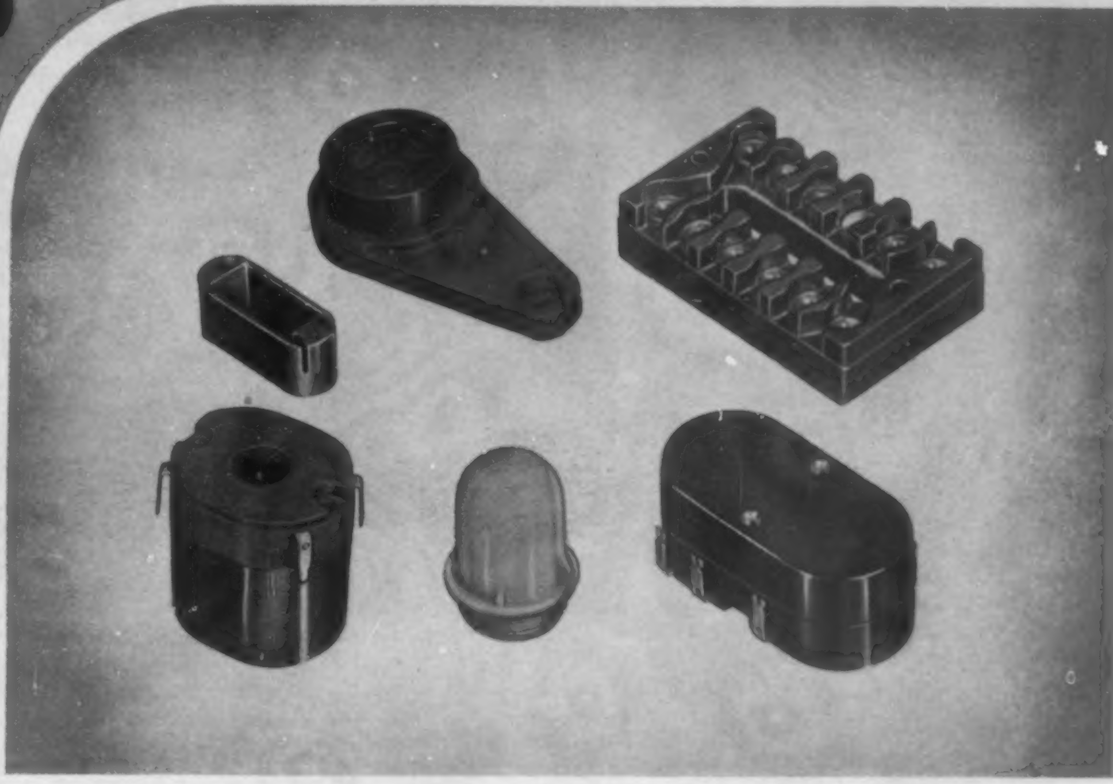
Other changes—If price increases have been granted to specific items prior to March 27, 1944 (effective date of MPR-523), they will be allowed to stand. A special sentence has been added to the order stating that it does *not* apply to natural or synthetic rubber or balata.

Trouble with mold shipments

Several tool manufacturers who provide dies and molds for the plastics industry have reported that trucking companies with whom they do business have refused to pick up less than 1000-lb. jobs unless they carried an AA1 rating.

A check in Washington has revealed that certain truck lines have received ICC permission to set up an embargo schedule which permits them to operate within certain weight ranges only. Regardless of that factor, it has been learned that priority ratings are not applicable to transportation and any person encountering the above condition should immediately notify the nearest ICC office.

PLASTICS



NEWS OF THE INDUSTRY

★ E. M. PRESSNER HAS RESIGNED as vice-president of Columbia Protektosite Co., Inc., Carlstadt, N. J., in order to manufacture plastic toys and novelties.

★ TWO NEW ADDITIONS TO THE staff of Radio Corporation of America, R.C.A. Victor Div., Camden, N. J., are Walter L. Tesch, who will serve as an application engineer on electronic power heating equipment, and Thomas F. Kenna, whose position will be that of a commercial engineer on high-frequency induction heating equipment.

★ THE NEW PLANT OF PLASTIC Process Co. is located at 662 No. Robertson Blvd., Los Angeles, Calif.

★ PIERCE PLASTICS, INC., ANnounces the removal of its offices from 116 First St., Bay City, Mich., to 6733 West 65th St., Chicago, Ill.

★ CHARLES H. HUNTON, FORMerly with the Molding Powder Sales and Technical Sales Div., E. I. du Pont de Nemours and Co., Inc., has formed the Hunton Plastics Co., 9 S. Van Brunt St., Englewood, N. J. The company will engage in the fabrication of various plastics materials.

★ LICENSES UNDER THE PATents of H. A. Leduc and R. A. Dufour—U. S. Patents 2,129,203, 2,163,993, 2,188,625, 2,261,847, 2,280,771 and 2,303,341, covering the application of high-frequency heating in the production, processing and manufacture of rubber, plastics, wood and other products—are now available in this country. The B. F. Goodrich Co., Akron, Ohio, will issue licenses on the patents covering rubber applications. H. H. Giodvad Grell, 33 University Place, New York 3, N. Y., will issue licenses on patents in all other fields.

★ RICHARD C. DUNLOP, FORMerly assistant research director of the Plastics Division, Monsanto Chemical Co., has been named associate research director. He will work with Dr. Nicholas N. T. Samaras who was recently appointed director of research. Howard Nason has been transferred to the company's Central Research Laboratories, Dayton, Ohio, in the capacity of director of development.

★ AN ENGINEERING AND SERVice office has been established by Hardinge Brothers, Inc., Elmira, N. Y., at 4460 Cass Avenue, Detroit, Mich. The office will be under Charles Boland.

★ THE PLASTIC DYE PRODUCT manufactured by Krieger Color and Chemical Co., Hollywood, Calif., formerly called "Lucidip," will now be identified by the trade name "Kriegr-O-Dip."

★ THREE NEW SALES OFFICES have been established by Standard Molding Corp., Dayton, Ohio: R. S. Christie & Co., 175 Fifth Avenue, New York City; Standard Molding Corp., 6452 Cass Ave., Detroit, Mich.; and Standard Molding Corp., 324 Chattanooga Bank Bldg., Chattanooga, Tenn.

DANIEL SZANTAY

★ DANIEL SZANTAY, WHO IS ONE of the pioneers in the field of injection molding, announces the formation of a new organization, the Santay Corp., to replace the Sinko Tool and Mfg. Co., Chicago, Illinois. The new corporation will carry on the high tradition of service rendered by the parent organization since its inception in 1925.

★ LESTER-PHOENIX, INC., CLEVEland, Ohio, has appointed Eccles and Davies Machinery Co., Inc., 1910 Santa Fe Ave., Los Angeles, as agents to handle their complete line of high-pressure die casting machines and injection molding machines.

★ AMERICAN SCREW CO., PROVIdence, R. I., has elected the following officers: Charles O. Drayton, vice-president in charge of sales, and George H. Reama, vice-president in charge of manufacturing.

★ THE FOLLOWING MEN HAVE been elected officers of American Society for Testing Materials: president, P. H. Bates, Chief, Clay and Silicate Products Div., National Bureau of Standards; vice-president, Arthur W. Carpenter, manager, Testing Laboratories, B. F. Goodrich Co. Members of executive committee are: W. C. Hanna, L. B. Jones, J. T. MacKenzie, J. C. Morrow and Sam Tour.

★ THE NEARLY 1600 STOCK molds in existence thoughout the country, and all of the developments and new information gathered in the stock mold field during the past two years, are incorporated in the new edition of Modern Plastics' Stock Mold Book. Each item listed represents a mold already made and ready for present-day or postwar use. For the first time, all extruded cross-sections appear in a single standardized index, and for ease of reference, the book is cross-indexed both by subjects and by names and addresses of the manufacturers represented. The price of the book is $5.00 per copy.

★ A NEW ORGANIZATION, TO BE known as Grayhill, has been formed by Ralph M. Hill and Gordon E. Gray, at 1 North Pulaski Road, Chicago, Ill., for the engineering and manufacture of mechanical and electrical switching devices. Position of chief mechanical engineer and general manager will be assumed by W. S. Lewis, while the plastic design engineering and production will be under the guidance of Arnold Wassell.

★ THE TITANIUM-DIOXIDE manufacturing facilities of the Virginia Chemical Corp., Piney River, Va., have been acquired by Calco Chemical Div., American Cyanamid Co., Bound Brook, N. J., from Interchemical Corp. With J. Allegaert serving in the capacity of manager, and A. B. Hattrick as resident manager of Virginia operation, this organization will be a unit of Calco's Pigment Department.

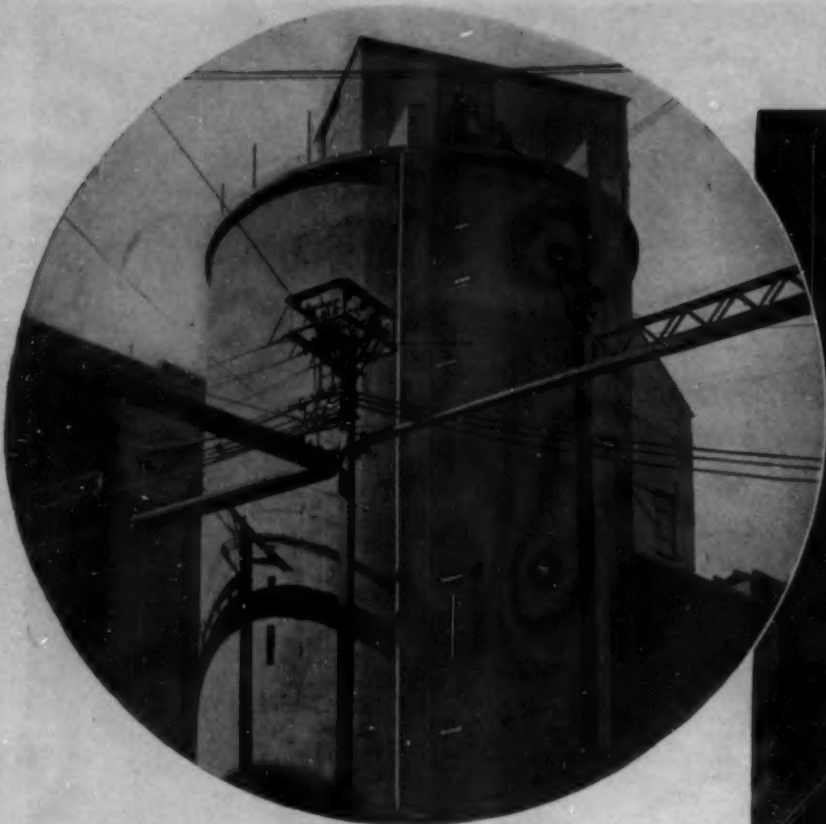
★ RUSSEL H. DUNHAM HAS REsigned from his position as chairman of the board of directors of Hercules Powder Co., Wilmington, Del., but he will remain as director and chairman of the finance committee. Charles A. Higgins, president, will fill the office of chairman of the board, vacated by Mr. Dunham.

★ THE ARMY-NAVY "E" HAS BEEN awarded to the men and women of Plastic and Die Cast Products Corp., Los Angeles.

Sorry!

★ WE REGRET THAT THROUGH an oversight, in the article, "Target Practice for a Blitz," which appeared on pages 98 and 99 in the June issue, we failed to mention that Mack Molding Ltd. and Bolta Plastics, Ltd. also mold the plastic parts used in this bomb as subcontractors of the International Flare Signal Co.

★ IT HAS BEEN CALLED TO OUR attention that in our mention of James Anderson of Dow Chemical Co. which appeared on page 156 of the July issue, we mistakenly stated that Mr. Anderson has been placed in charge of the Plastics Engineering Div. Mr. Anderson is in charge of sales promotion for the Plastics Engineering Div. of Dow Chemical Co. while Donald L. Gibb is head of the division.



Exterior and interior views of the resin dryer which reduces the synthetic resin plywood adhesives from a liquid to a powdered state, thus simplifying the problem of shipment

A resin-powdering unit

WITH the tides of war daily converging on several focal points from which all succeeding operations of attack will stem, the need for speedier and more concentrated shipping of essential war materials from manufacturers in the United States to various overseas ports for on-the-scene assembly grows more urgent. Such a necessity is largely responsible for the recent development by Resinous Products and Chemical Co., Inc., of a resinous adhesive dryer, one of the largest of its kind in the world. Through the use of a recently discovered process, this dryer reduces the synthetic resin plywood adhesives—a basic product in the construction of barges and landing boats—from a liquid to a powdered state, thus enabling larger quantities of the resinous product to be shipped in the same space as previously occupied.

Not only does the powdered resin save bulk and weight but it permits the use of containers made of a non-critical material. Further, it doubles the storage life of the resin—an important consideration in wartime in view of the close calculation necessary to utilize every square inch of shipping.

The new resin-powdering unit, which employs a spray-dry method of manufacture, bears a close resemblance to a great "gas-holder" both in its shape and in its size. Such a vast capacity was dictated by the increasing uses for synthetic adhesives in the production and assembling of plywood gliders, airplanes, torpedo and assault boats, soldiers' barracks, military truck bodies, shipping crates, skis and snowshoes. Resinous adhesives in their liquid form are pumped to the top of a hot-air chamber, four stories in height. Here they are converted into a "fog" by the concentrated action of a high-speed centrifugal wheel. As the liquid becomes vaporized it falls to the floor of the drier in the form of a very fine powder. It is picked up at this point by a revolving knife blade which first brushes the powder into ducts and then deposits it in collectors where all air is completely removed. Conveyors are on hand to carry the resinous deposit over screens and into shipping drums.

Because of the immediate need for these resins and the important part they play in fashioning the vital implements of war, engineers concerned in their manufacture were given unlimited priorities by the War Production Board in the procurement of the various parts needed in the making of the machine. However it was found that the great drier could be completed more quickly and economically if salvaged and second-hand equipment which was readily available was utilized in its construction.

The creation of so vast a project as this mammoth drier which, according to its manufacturer, turns out almost fantastic amounts of powdered resin when working to full capacity, is a most noteworthy achievement in the production of resinous adhesives. It reflects the tremendous increase in the use of both urea and phenolics in the fields of paper, fiberboard and plywood as well as in aircraft and marine activities. Too, it indicates the growing reliance of major industries on the newly developed synthetics.

Safety helmets

(*Continued from page 83*) plastic material has the same heat insulation qualities as pulp covered with cloth, a 250-watt reflector drying lamp was installed 12 in. above the helmet. A small thermometer was placed so as to contact the top of the helmet's outer surface while another was located inside the head guard in contact with the inner surface. All experiments were conducted from a room temperature of 70° F., when the helmets were placed in the apparatus and readings were taken every 30 minutes. The following tabulation shows the results of the test over a $2^1/_2$ hr. period.

	$^1/_2$ *hr.*	1 *hr.*	$1^1/_2$ *hr.*	2 *hr.*	$2^1/_2$ *hr.*
PULP HELMET					
Outside reading, ° F.	136	144	152	155	165
Inside reading, ° F.	142	146	148	151	152
PLASTIC HELMET (SHINY FINISH)					
Outside reading, ° F.	148	146	146	147	144
Inside reading, ° F.	150	154	152	153	150
PLASTIC HELMET (OLIVE DRAB FINISH)					
Outside reading, ° F.	145	150	162	160	160
Inside reading, ° F.	180	185	185	180	180

One of the interesting sidelights of this test was the degree to which the rough unfinished olive drab surface of the helmet absorbed heat compared with the reflective power of the shiny finish of the plastic helmet which helped reduce temperature.

Another test was conducted by company technicians to determine the effect of adequate air circulation space inside the helmet between the head and the suspension. For this test a thermometer was placed inside the helmet one inch away from the inside of the crown. Readings were taken at several stations over a $2^1/_2$ hr. period at 30 min. intervals. The results were uniform—inside readings dropping back on the average of about 25 percent from outside readings. Generally the higher the outside readings the greater the decrease in temperature inside the helmet because of the effects of the air circulating space.

To simulate an outdoor temperature of 100° F., the tests were re-run with the inside readings taken one inch away from the crown. The tests showed that the high-finished plastic material, either in natural color or green, had the lowest inside temperature readings.

In order to obtain a clear picture of the heat-resisting properties of the helmet materials, another test was run in which metal, pulp and plastic helmets were compared. The method and equipment included provision for temperature readings from four stations: Number 1, a thermocouple reading $^1/_4$ in. from the outside of the helmet; Number 2, a reading touching the outside of the helmet; Number 3, a reading $^1/_4$ in. away from the helmet on the inside; Number 4, touching the inside of the helmet. An infra-red lamp placed a distance of $2^1/_4$ ft. was used in the tests. The results are shown in Table I. Later, the same procedure was employed in a comparison between a plastic and an aluminum helmet.

From a reference to Table I, Test No. 2, it would appear that plastic helmets have a lower inside temperature and have the added advantage of being non-conductors of electricity. The tests also indicate that unbuffed copper plating in the thickness of 0.001 in. is the best from the standpoint the heat refraction and comfort to the wearer.

Other tests were conducted on various helmets with a view to obtaining information on the resistance of the helmets to mildew, fungus growth and delousing operations. For use under tropical and sub-tropical conditions, the headbands have been proofed against mildew and, in certain applications, a fractional amount of barium sulfate is included in the laminate. Should the helmet be punctured and a portion of the material lodge in the brain, it would be instantly visible under x-ray, since barium sulfate is readily radioactive.

One experiment was carried on with respect to excessive noise in the helmets, of which some wearers complained. Results indicated that without air circulation holes around the upper crown, noise was kept to a minimum. Changing the over-all shapes did not seem to reduce the noise factor nor did the holes in the brim to which the suspensions were anchored. The same principle as that which comes into play when air is passed across the neck of a bottle obtains in the helmet—holes must be present to cause a whistling sound. However, at this point psychology enters the process of manufacture. Tests to the contrary notwithstanding, field reports indicate that if holes for the head suspension are omitted, men in the field will make their own insertions in

4—The serrated fingers in the laminate sections that make up the safety helmets give added strength. 5—The assembled sections are placed in a low-pressure press where the helmets are molded in a 4-min. cycle

PHOTOS, COURTESY PARAMOUNT RUBBER CO.

4

5


Thin or Thick
Specify
AUTO-LITE
PLASTICS
FOR THE DURATION . . . AND AFTER

the belief that by so doing they will increase the circulation of air and reduce the noise of whistling.

Where the riveted-type of suspension is specified, an artificial leather sweatband treated to resist mildewing and tropical deterioration is used with coated steel clips. Where the cradle-type suspension is employed, string, webbing and artificial sweatbands are treated with "aquanil" and made resistant to mildewing and tropical deterioration. In practice, the company has provided the cradle-type suspension for industrial safety helmets—testing 80 or more ft.-lb. impact. However, this suspension is omitted in the sun safety helmets.

In addition to the conventional insurance and underwriters tests, the service specifications of the Model M plastic sun and safety helmet are of interest. These helmets, designed for the Armed Forces, call for 8 oz. enamelling duck with a 200 lb. tensile pull, warp, and a 144 lb. pull, filling. The resin is of the low-temperature formaldehyde type with an impregnation of 52 percent and limitations of 6 to 7 percent volatility with a flow of 34 to 36. The material is the same as has been used and specified in the M-I combat helmet liner of which more than 3,000,000 have been manufactured. For service use, olive drab finish in a baked enamel is specified.

Special attention has been given in these helmets to the brim design. The short front brim is intended to give the wearer a wide upward angle of vision and shelter from the glare of the sun while, at the back, protection is provided for the rear of the head and the neck. Specifications covering the parts to be used in the manufacture of these sun helmets call for two laminations in the crown of the helmets and three in the brim and head sections. Doubled up overlapping sections provide additional strength without any increase in weight due to the use of the cantilever principle in design. The helmet brim is molded to the crown by reinforcing diamond-shaped pieces.

Tests for quality as set forth in the specifications for the plastic sun helmet state that the head guard must withstand a deadweight of 150 lb. or more and have an impact strength of 20 ft.-lb. plus. The permissible water absorption is limited to 1.5 percent when a helmet is immersed for 48 hr. in hot or cold water. With the suspension removed, the helmet must withstand 17 lb. of steam at 253° F. Over a 30 min. period this temperature is considered to be adequate to destroy typhus spores and lice. No dimensional change is permitted in this test. The plastic material in the helmet laminations is proofed against ravages of white ants and other tropical insects. Tensile, burning and flexing tests are identical with those for the M-I combat liner.

Though the company is concentrating on 4 types of plastic helmets, development is proceeding along other lines. A low-pressure laminated welder's shield is at present in the process of development.

Credits—Material: Bakelite, Durez and Durite. Helmets molded by Paramount Rubber Co. Plating by Monroe Auto Equipment Co.

TABLE I.—HEAT-RESISTING PROPERTIES OF HELMET MATERIALS

	Outside station		*Inside station*	
	Number 1 (1/4 in. away)	*Number 2 (Touching)*	*Number 3 (1/4 in. away)*	*Number 4 (Touching)*
Test Number 1:				
1. Unplated helmet, ° F.	153	202	158	179
2. Unplated helmet, ° F.	152	176	158	168
3. Unplated helmet, ° F.	156	198	162	186
4. Unplated helmet, ° F.	147	180	157	167
5. Plated copper crown, 0.0015 in., non-buffed surface, ° F.	137	126	94	99
6. Re-run of No. 5., ° F.	141	127	93	98
7. Same helmet as No. 5 with buffed surface, ° F.	137	141	110	118
8. Re-run of No. 7, ° F.	143	137	107	116
9. Unbuffed copper coating 0.001, ° F.	142	123	93	98
Test Number 2:				
1. Plated plastic helmet	129	120	88	89
2. Plated plastic helmet	129	123	91	91
3. Aluminum helmet	120	120	102	106
4. Aluminum helmet	120	117	110	104

PHOTOS, COURTESY PARAMOUNT RUBBER CO.

6

7

6—All holes, which are used to anchor the suspension ties, are punched in one operation. 7—To trim flash from the helmet brim, the plastic helmet is placed over a block where a milling tool removes the rough edges

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VINSOL* RESIN

PROPERTIES:
A dark colored, hard, brittle, high melting (112 to 115C) resin that is saponifiable—gasoline insoluble—soluble in aromatics—thermoplastic—compatible with many molding compositions—has excellent electrical properties—and under proper conditions will react with formaldehyde to form thermal setting resins.

USES:
Rubber compounding—floor tile mastics—electrical insulating compounds — thermoplastic and thermo setting compounds—shellac substitutes — varnishes and lacquers — fiber board stiffener — emulsifier — specialty adhesives — plasticizer in masonry cement — thermoplastic binder—extender for phenolic resins—and many other uses which call for a dark colored resin.

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Behavior of plastics

(Continued from page 128)

24. "Static and Dynamic Strength Properties of Light Metals," by K. Matthaes, VDL Jahrbuch 439–84 (1931), Fig. 56 and 57.

Damping and dynamic modulus

25. "Damping Properties of Non-Metallic Materials," by G. Parzich, Forschung auf dem Gebiete des Ingenieurwesens *4*, 8–10 (Jan.-Feb. 1933).

26. "A Property of Synthetic Resins," by N. A. DeBruyne and J. N. Maas, Aircraft Engineering *8*, 280–90 (1936).

27. "Measurement of Solid Friction of Plastics," by A. Gemant, J. Applied Physics *11*, 647–53 (1940).

28. "Frictional Phenomena. XIII. Internal Friction in Solids," by A. Gemant, J. Applied Physics *14*, 204–16 (1943).

29. "Creep, Elastic Hysteresis and Damping in Bakelite Under Torsion," by H. Leaderman, J. Applied Mechanics A79–A85 (June 1939).

30. "Some Mechanical Properties of Plastics and Metals under Sustained Vibrations," by B. J. Lazan, Trans. A.S.M.E. *65*, 87–104 (1943); Modern Plastics *20*, 83–88, 136, 138, 140, 142 (Nov. 1942).

31. "A Dynamic Method of Measuring the Elastic Constants of Materials," by B. J. Lazan, unpublished work done at Harvard University during 1938.

32. "Temperature Dependence of Young's Modulus and Internal Friction of Lucite and Karolith," by J. S. Rinehart, J. Applied Physics *12*, 811–6 (1941).

33. "The Damping Capacity of Engineering Materials," by W. H. Hatfield, G. Stanfield and L. Rotherham, N. E. Coast Institution of Engineers and Shipbuilders, 273–352 (May 15, 1942).

34. "The Practical Importance of Damping Capacity of Metals, Especially Steels," by O. Foppl, J. Iron and Steel Institute *134*, 393–455 (1936).

35. "Damping Capacity of Materials," by G. S. von Heydekampf, *31*, Part II, 157–71 (1931).

36. "Some Dynamic Properties of Rubber," by C. O. Harris, J. Applied Mechanics (June 1943).

37. "Present-Day Knowledge of Fatigue," by A.S.T.M. Fatigue Committee, Proc. A.S.T.M. *30*, Part I, 260–310 (1930).

Aqua dyes

(Continued from page 90) spent the last 12 years with his hands in dye vats of one sort or another—working chiefly with plastics in recent years. "I don't know what makes this water dye work on acrylics," he says. "It is still a mystery to me. The color doesn't go all the way through, of course, but it seems to. We can get a beautiful ebony-black under the right conditions and conclusive tests prove it will not fade (see Table I).

"We make acetone dyes too," he continued, "but I believe the water dyes will supplant them before long. They are easier to use and much faster, and they do away with the necessity of storage in fireproof rooms. Even at high temperatures there are no toxic or disagreeable fumes thrown off by the water dye, and there is no danger from combustion and fire."

Mr. Schwartzman has just completed dyeing some big sheets a ruby-red for the Navy. They are to be used as signal lights on ships. This water dye is also being used experimentally for coloring sections of acrylic aircraft turrets to protect pilots from ultraviolet light. A shade of polymerized green, similar to the color used for sun glasses, is applied by dipping the designated portion of the shaped turret in the hot dye bath. The surrounding material may be kept clear by masking, or the dye may be removed by buffing from portions where it is not wanted.

Thirteen standard colors have been worked out in the water dyes. They come in a thick concentrate hardly more fluid than paste. The concentrate is instantly soluble in water, and about 12 oz. of dye is sufficient for a gallon of water, making a little more than a gallon of dye. One pound of dye (about one pint) will dye 16 sq. ft. of plastic material to maximum color strength. Lighter shades, of course, require less dye. The dye is added to cold water, then brought to the proper temperature for the best dyeing results. For acrylics, the most satisfactory temperature is 190° F.; for acetate, the temperature must be kept under 140° F. or the material will blush. For uniform results the matter of temperature is critical, and the depth of color is controlled by the length of time the piece is submerged in the dye bath. Usu-

TABLE I.—TECHNICAL DATA ON WATER DYE

TEMPERATURE TESTS

Specimens used: Plexiglas $^1/_8 \times 2 \times ^3/_4$ in.
Proportion: 10 percent concentrate
90 percent water

Temperature:
1st test, 140° F.
2nd test, 170° F.
3rd test, 190° F.

Immersion time (for each test): $^1/_2$ min., 1 min., $1^1/_2$ min., 2 min.

Result: Although proportion of concentrate used for the 3 tests was the same, the samples showed a deeper color in proportion to the higher temperature of the solution.

Conclusion: 1) Dye solution should be kept at about 190° F. constantly in order to obtain best results, full strength of dye and uniformity of color. 2) Strength of solution is not governed by proportion of concentrate beyond 10 percent, but by temperature.

STRENGTH OF DYE TEST

Specimens used: Plexiglas $^1/_8 \times 2 \times ^3/_4$ in.
Proportion: 10 percent concentrate
90 percent water

Temperature: 190° F.
35 pieces immersed for 3 min. gave maximum color; next 10 pieces immersed for 3 min. gave color equal to 1 min.; next 10 pieces immersed for 3 min. gave color equal to $^1/_2$ min.

Conclusion: 1) Twenty-five grams of concentrate are sufficient to dye an area of 128 sq. in. at maximum strength. Dye solution is still good to cover a similar area, but shade will be much lighter. 2) A comparison test made with an acetone dye showed that after 144 sq. in. were dyed at maximum strength, the acetone dye had lost its potency in the same manner as the water dye.

SUN TEST

Specimens used: Plexiglas $^1/_8 \times 2 \times ^3/_4$ in.
Proportion: 10 percent concentrate
90 percent water
Temperature: 190° F.
Colors: blue, red, yellow

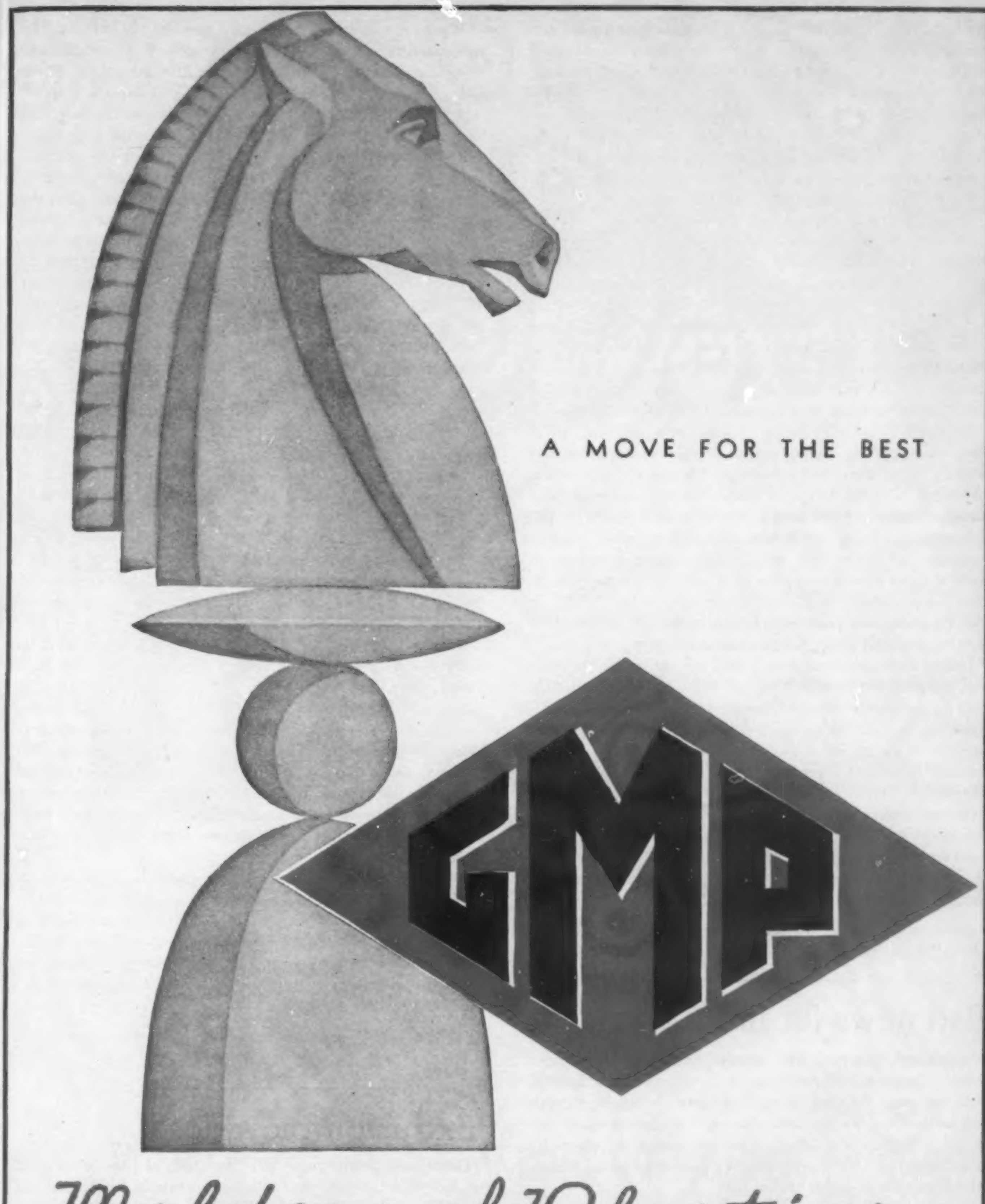
Immersion time: $^1/_4$ min., $^1/_2$ min., 1 min., $1^1/_2$ min., 3 min.

Samples: Five for each color were masked with black tape leaving only center of each piece uncovered. Length of of test under sunlamp: 48 hr., equal to 2 weeks of exposure to sunlight.

Result: After the masking tape was removed, not even a faint discoloration could be noticed.

ADVANTAGES OF WATER DYE

No danger from combustion or fire.
No odor or toxic fumes.
Surface of plastic is not affected.
Control dye strength by controlling temperature of solution.
Only quantity of concentrate needed is used. This is determined by the knowledge of the following formula: 25 gr. concentrate to 225 gr. water at 190° F. will give maximum strength for 128 sq. inches.
Dye solution can be kept for use again if lighter shade is required. Material is not contaminated, evaporates slowly if at all.
Cost will be less than for other dye.
Bulk factor is also important, as 1 gal. of concentrate equals the dyeing efficiency of 9 gal. of acetone dye.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ally from 10 to 15 sec. are all that is necessary for a good dispersion of color. It is better to give the piece a second dip if deeper shades are desired than to leave it in the bath too long at one time. This is especially true of formed parts which may distort or flatten out if kept at high temperatures too long. Since a variance of even 10° will make a difference in the color of the finished piece, the best equipment for this work is a steam-heated vat with thermostatic controls.

Some acrylics take dye more slowly than others. In addition, if the acrylic parts are wet before dyeing, they will take the color more rapidly than if placed in the solution dry. In this way, maximum production can be speeded after the time cycle has been worked out on a few experimental parts.

There is real economy in using water dyes because one gallon of concentrate, which sells at about $12, will do the same amount of dyeing as 9 gal. of acetone dye which sells at about $5 a gallon. The concentrate saves storage space, is cheaper to ship and safer to use. Furthermore, water is much easier to obtain than acetone and cheaper.

Available colors are: yellow, rubine, red, sky-blue, royal blue, orange, black, amber, scarlet, purple, violet, green and brown. Since the colors are compatible one with the other, an almost unlimited variety of shades can be mixed from these standard colors. For example, amber with a touch of sky-blue gives chartreuse. Sky-blue with a bit of yellow becomes turquoise. A little blue with purple makes aquamarine. Rubine gives a wide variation of shades from light pink to deep maroon simply by varying the time of the bath. Purple used for a quick dip produces a beautiful shade of orchid which may be deepened as desired by subsequent dips.

Unless they penetrate deeply into the surface of the plastics, colors may be buffed off at will. This opens a wide field for imaginative decorative effects since patterns and designs can be buffed clear on a colored sheet. Masking also suggests a variety of decorative effects. A design may be masked on a dyed sheet and the surrounding color entirely removed by buffing. This leaves the design, clear cut in color, on a clear transparent sheet. When this war is over the world will be tired of the drab tones with which it has lived so long. Clear transparent plastics will still have their place in decorative fields, but color will have a special appeal—inviting sales.

Credits—Water dyes: Great American Color Co. Tests by Multi-Plastics Corp.

Bad news for fish

(Continued from page 84) ferrules and other component parts. Each step is performed by craftsmen long familiar with the exact dimensions and tolerances required to create the predestined weight and balance of each individual rod. It is understandable that, since impregnation alters the characteristics of the bamboo, new problems were created which necessitated new techniques.

Among the many points of superiority claimed for the impregnated rod are: 1) complete sealing with phenolic resin—inside and outside—produces a solid integral waterproof structure that is said to be impervious to boiling water or temperatures below zero; 2) stays "young" longer; 3) with reasonable care, rod resists a "set" indefinitely; 4) requires little upkeep since there is no varnish to replace. On the strictly sporting side, it is claimed that the "dark brown, dull satin finish of the rod prevents sun reflection and glitter when casting."

When war was declared, the company undertook the manufacture of ski poles for the Army, using phenolic impregnated bamboo poles in place of tubular steel. These poles proved to be stronger than steel and did not snap off due to crystallization. If one did break, the fracture was not usually compound. In many instances, the pole could be well enough repaired with tape to permit the skier to return to base. The stiffness and waterproof characteristics of the impregnated poles under extreme temperature changes, combined with the natural strength of the bamboo, produced a product of great popularity with the ski troops. The ever-increasing popularity of winter sports and the return to civilian life of thousands of men trained for winter combat suggest an extensive postwar market for these plastic-impregnated ski poles.

Manpower shortages have caused a sharp reduction in the company's production, and War Production Board allocations permit the manufacture of only 1200 fishing rods this year with orders far exceeding capacity. Meanwhile, experimental work continues on golf clubs, billiard cues, violin bows and even baseball bats. It is said that wonderful distance can be obtained with the golf club and, in a long iron shot to the green, a highly desirable sharp back spin can be put on the ball. The billiard cue is expected to be very popular because the impregnated split bamboo will not warp and become crooked. As in the case of the golf shaft, the touch is new and unusual, and it is possible to produce a hollow cue tip to save weight and impart perfect balance.

The violin bow, unlike any of the other articles, must be formed into a definite permanent curve. While the resin impregnated bamboo will resist "set" when straightened, it also resists straightening when "set" into a particular curve. The extremely delicate taper and balance which is necessary on the bow can be procured with impregnated bamboo since, like that of the fishing rod, the taper can be reduced at any point by fine hand sanding, and the proper balance can be obtained in regulating the arc by extremely careful heat treating over a Bunsen burner. The bow can be made round, hexagonal or octagonal.

The successful impregnation of split bamboo with a phenolic resin promises improved products in other fields, and the Orvis company currently is deep in experimental work on furniture and interior decorations such as paneling and screens. In the sports field, development continues on archery equipment, vaulting poles, tennis racquet frames and landing net frames.

Credits—Material: Bakelite. Fishing rod manufactured by Charles F. Orvis Co., Inc.

Extrusion blowing

(Continued from page 81) because of its brittleness. It has the advantage over cellulose acetate of better thermal stability and resistance to cold flow, much lower moisture absorption and hence higher volume stability. In addition polystyrene lacks the objectionable effects of a volatile plasticizer. Research and development in either forming processes or material composition, or both, give promise of such improvements as to make containers of polystyrene or modified polystyrene equal, if not superior in all respects, to those made of cellulose acetate or of other cellulosic compounds.

Another advantage of the polystyrene container which opens wide fields of application is its nearly universal re-

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COMPRESSION, INJECTION, AND TRANSFER MOLDING OF ALL PLASTIC MATERIALS

25 years of Progress and Achievement

sistance to acids and alkalis. However, an executive of the company brought forth one hitherto little-known disadvantage of polystyrene—that it cannot be used as a universal container material and, therefore, he did not feel that druggists would substitute plastic containers for their present stocks of glass bottles to any large extent. He also stated that some tinctures attacked polystyrene and that oils at elevated temperature affected it. Specifically, the alcohol in the tincture does not attack the container but the actual tincture itself is the culprit. The higher price of the polystyrene container may prevent its use in competition with the lower-priced glass container.

Of course, in the container field, price is an important factor. Roughly, a thermoplastic container weighing approximately one-third as much as a glass container of equal volume would cost three times as much. With glass material at $^3/_4$ of a cent per pound, it would be rather difficult to put out a container in polystyrene, acetate or, for that matter, in any of the plastics at a price as low as that of a similar container in glass.

There are, however, many applications in which the plastic container would be specified in preference to glass because of one or more of the inherent physical properties of the plastic which would make its use advantageous or, in some cases, necessary. For example, the styrene bottles may develop a very large field of application in the packaging of mineral acids, particularly such acids as hydrofluoric acid. Figure 1 indicates a few of the possible applications of this process for forming hollow articles. It also indicates the eye appeal of a variety of items when produced in plastics.

Due to the restrictions of the war, the amount of equipment available for the production of containers is necessarily limited. New and much enlarged equipment is planned for the postwar period—including equipment to manufacture larger and smaller items than can be advantageously blown today. This will assist in the production of cheaper containers at higher speed and in greater quantity. Present equipment roughly limits production to a minimum of $^3/_4$ in. in diameter by $1^1/_2$ in. in height up to a maximum of $4^3/_4$ in. in diameter by $7^1/_2$ in. in height. Within these limitations a tremendous number of variations from standard round or spherical containers can be obtained. The square bottle shown in Fig. 1 is an example.

The extent to which plastic containers made by the blowing process will be used is still conjectural. Many new uses have been developed by the war. However, it is apparent that the limitations of the plastic materials themselves restrict the field of application. In the cosmetic and drug fields a ready and wide application is apparent, but a wider use of the processes depends upon the development of a somewhat more universal plastic than is now known. Finally, in the postwar market, a lower raw materials' price will be absolutely imperative.

High-temperature styrene

(*Continued from page 93*) frequency and super high-frequency insulating parts. Data on such applications are restricted and cannot be published at present.

The high heat resistance of polydichlorostyrene is not accompanied by the need for unduly high molding temperatures. Although the molding range of 475 to 550° F. is somewhat higher than that of materials in wide use, it is still within the range of standard injection or extrusion machines. The

TABLE I.—PROPERTIES OF POLYDICHLOROSTYRENE

	A.S.T.M. test No.	*Styramic HT, polydichlorostyrene*[a]	*Polystyrene*[b]
Moldability in injection molds		Very good[c]	Excellent
Injection molding temperatures, °F.		475–550	400–450
Compression molding temperatures, °F.		360–400	325–350
Machining qualities		Very good	Very good
Specific gravity		1.38	1.05–1.07
Water absorption, 24 hr., percent	D570–42	0.03	0.05
Flammability, in./min.	D568–41T D635–41T	Self extinguishing	1.0
Heat distortion point, °F.	D648–41T	236	168–176
Rockwell hardness	D229	M103	M80–M90
Dielectric constant, 1000 cycles	D150–42T	2.62	2.5–2.6
Power factor, 1000 cycles	D150–42T	0.0002	0.0001–0.0003
Dielectric constant, 1,000,000 cycles	D150–42T	2.62	2.5–2.6
Power factor, 1,000,000 cycles	D150–42T	0.0002	0.0001–0.0003

[a] All data on Styramic HT, Monsanto Chemical Co.
[b] All other data on polystyrene, PMMA "Technical Data on Plastic Materials."
[c] Moldability in extrusion machines is excellent.

material has excellent color possibilities—being basically a clear transparent—although its applications are not likely to be those in which color or appearance is of prime importance. Polydichlorostyrene is nonflammable and is self-extinguishing when subjected to the A.S.T.M. flammability tests.

As stated previously, production of the new compound is on a pilot plant scale, and the material is available only in very small quantities for direct military applications.

Allyl plastics

(*Continued from page 99*) the measurement of haze resulting from accelerated weathering, except that stops were employed to reduce the area of the light beam so that only the uniformly abraded areas of the plastic were covered. In connection with these tests, subjective service tests were carried out which indicated that haze values in excess of but 5 to 10 percent became intolerable in a glazing material—particularly if night vision against the glare of lights was required. Consequently, haze values above this range were regarded as constituting failure for glazing applications.

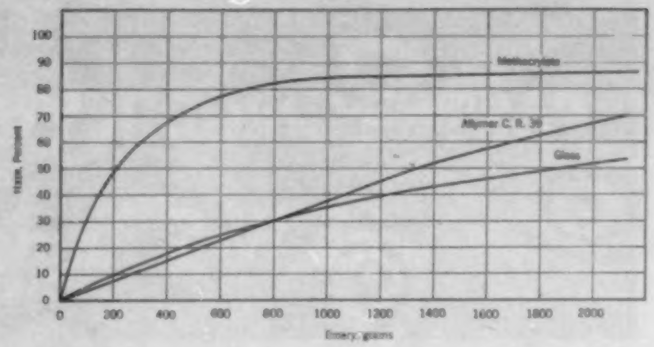
The test results given for Allymer C.R. 39-1, a special modification of Allymer C.R. 39 which is resistant to yellowing upon weathering and was developed for transparent sheets, and the results for the other cast polymers presented in Table I, show some of the possibilities for development of specific allyl compounds which emphasize particular properties. It will be observed that the mar resistance of Allymer C.R. 39-1, of importance in clear sheets, is somewhat higher than for 39Bd or 149. On the other hand, the other two materials possess higher flexural and compressive strengths and greater moduli of elasticity than Allymer C.R. 39, and they yield superior laminates, particularly when high-strength fibers, such as glass fibers, are used.

Properties of comparatively high-strength laminates of

Allymer C.R. 39Bd and Allymer C.R. 149 prepared using OC-64 Fiberglas fabric, are summarized in Table II. The effects of orientation of the plies of this unidirectional (with respect to glass threads) fabric in the laminates are shown by the comparison of the two Allymer C.R. 39Bd laminates prepared from the heat-treated fabric. The high tensile strength contributed by the glass fiber is concentrated in the direction of orientation of the glass threads. Therefore, it is apparent in only one of the two principal directions of the first laminate, but is distributed equally in these two directions in the laminate prepared by crossing successive plies at 90°. Most of the properties of these glass fiber laminates are improved by a heat treatment of the fabric, which partially removes the lubricant used in spinning and weaving and improves the wetting of the fabric by the allyl compound. These improvements are shown by a comparison of the Allymer C.R. 39Bd laminates of crossed construction prepared using the standard and the heat-treated fabrics.

Test results of the type represented by the graphs given in Fig. 1–5, inclusive, show that most of the properties of the laminates are influenced by the properties of the resin. While these results show that the dependency upon the resin is only slight with regard to tensile strength, it is great in the case of modulus of rupture, flexural modulus of elasticity, compressive strength and hardness. It is evident that the nature of the resin or plastic employed is to be a highly important factor in the development of these high-strength composites, particularly if a balance in properties similar to that existing in metals is to be attained.

A comparison of the properties shown in Table II for Allymer-Fiberglas laminates with the corresponding properties of aluminum alloy 24 ST, is made on an equivalent weight basis in Table III. These laminates, admittedly anisotropic, are nevertheless approximately balanced in specific properties with reference to the alloy in the two principal directions in which the measurements were taken. A definite superiority is indicated for the laminates in some of the specific strength properties listed. Test samples cut



3—Falling emery mar resistance, modified A.S.T.M.

TABLE III.—COMPARATIVE SPECIFIC STRENGTHS (STRENGTH-WEIGHT RATIOS) OF ALUMINUM ALLOY AND LAMINATES MADE WITH ALLYMER RESINS AND HEAT-TREATED CROSSED-PLY OC-64 FIBERGLAS FABRIC

Property	Specific strength[a] Allymer C.R. 39Bd laminate	Allymer C.R. 149 laminate	Aluminum Alloy 24 ST
Ultimate tensile strength, p.s.i.	28,000	30,600	22,400
Tensile modulus of elasticity, p.s.i.	1,680,000	1,630,000	3,800,000
Modulus of rupture, p.s.i.	21,100	27,400	8100
Flexural modulus of elasticity, p.s.i.	340,000	445,000	495,000
Compressive strength, edgewise, p.s.i.	23,000	31,100	23,500
Tangent proportional limit, p.s.i.	20,700	30,200	10,800
Compressive modulus of elasticity, p.s.i.	1,170,000	1,350,000	3,800,000
Shear strength, p.s.i.	12,200	15,200	14,200

[a] Computed from data given in Table II, and from values for aluminum alloy 24 ST given in ANC-5, "Strength of Aircraft Elements," Dec. 1942. Specific modulus of rupture = actual/(sp. gr.)^2; specific flexural modulus of elasticity = actual/(sp. gr.)^3; all other specific values = actual/(sp. gr.).

TABLE II.—PHYSICAL PROPERTIES OF ALLYMER-FIBERGLAS[a] LAMINATES

Property	Allymer C.R. 39Bd[b] heat-treated fabric Warp	Fill	C.R. 39Bd standard fabric (plies crossed)	C.R. 39Bd heat-treated fabric (plies crossed)	C.R. 149 heat-treated fabric (plies crossed)
Density, 25° C.	1.77		1.89	1.85	1.75
Percent resin	41–44		39	40	40
Hardness,					
Rockwell—M	108		107	113	117
Barcol	57		45	60	70
Cold flow, Barcol	6		7	5	3
Ultimate tensile strength, p.s.i.	85,000–100,000	4,600	54,100	53,400	53,400
Tensile modulus of elasticity, p.s.i.	4,160,000	1,010,000	2,600,000	3,100,000	2,840,000
Ultimate modulus of rupture, p.s.i.	113,500	6600	55,500	72,200	87,800
Flexural modulus of elasticity, p.s.i.	3,320,000	1,130,000	2,650,000	2,150,000	2,640,000
Ultimate compressive strength,					
Edgewise, p.s.i.	60,700	20,600	28,000	42,500	54,400
Tangent proportional limit, p.s.i.	59,600	12,250	26,500	38,300	52,900
Compressive modulus of elasticity, p.s.i.	3,320,000	10,050,000	2,310,000	2,160,000	2,360,000
Shear strength, p.s.i.	29,200	5400	...	22,500	26,500
Fatigue limit, 10^7 cycles, p.s.i.	...	...	...	22,500	...
Bonding strength, p.s.i.	1980	...	1260	1800	1849
Impact strength, ft. lb./in., notched Izod	over 25.3	1.1	30	27	over 26
Water absorption, 24 hr. at 25° C., percent	0.4		1.9	1.4	0.3
Acetone absorption, one week at 25° C., percent	0.7		1.7	0.7	0.2

[a] OC-64 Fiberglas fabric; glass warp, muslin fill; thread count, warp 51/in., fill 30/in.
[b] Fabric plies oriented with all warp threads parallel.

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parallel with the glass threads from Allymer C.R. 149 laminates of the heat-treated unidirectional glass fabric, corresponding to the unidirectional Allymer C.R. 39Bd laminate shown in Table II, have given actual ultimate flexural strengths as high as 165,000 p.s.i. and actual shear strengths across the glass threads of 39,000 p.s.i., or values approximately the equivalent of 18-8 stainless steel in flexure and aluminum alloy 24 ST in shear strength.

Uses

The uses of the allyl plastics that have been developed thus far have been of a military type in which the new combination of properties or new methods of handling, have enabled them to perform new or critical functions better than other available materials or to perform functions not possible with these other materials. For example, the form stability of transparent sheets of the cast polymers under heat and low weight have led to their use as inner panels of aircraft heated-air de-icing windows. The optical clarity of these sheets has resulted in their use as special sight windows. The combination of solvent resistance, transparency, low weight and shock resistance has served as a basis for the use of cast sight gages.

Laminated allyl plastics have been employed as tough, light-weight supporting panels for self-sealing aircraft fuel tanks, and as light-weight strong cylindrical containers for water and for aircraft de-icer fluid. Simplified contact-pressure methods have been employed for fabrication of light-weight smooth sections of aircraft having complicated shapes.

While the above applications may be regarded as indicative of probable postwar applications, the exploration of the field of peacetime uses remains largely untouched. It is expected that these uses, as in present applications, will be of a type in which the new combination of properties exhibited by the allyl materials will serve as a basis for the simplification of fabricating operations in the development of new products.

The possibilities of modification and development toward specific properties and uses are inherently very great in these new thermosetting materials, and the development of new forms may be expected. A modification exhibiting promise for use in protective coatings, for example, is at present under development. The eventual production of compositions suitable for molding appears probable.

At present, the allyl thermosetting plastics must be classed with the premium plastics because of their limited production. However, the essential raw materials are basically cheap and, with continued development into the postwar period, these materials may be expected to take their place with the lower-cost members of the plastics family.

4 and 5—Correlation of properties of cast allyl resins with those of allyl resin-heat cleaned glass fiber crossed laminates. 6—Taber mar resistance using CS-10 wheel. 7—Correlation of Rockwell-M hardness of resin and laminate

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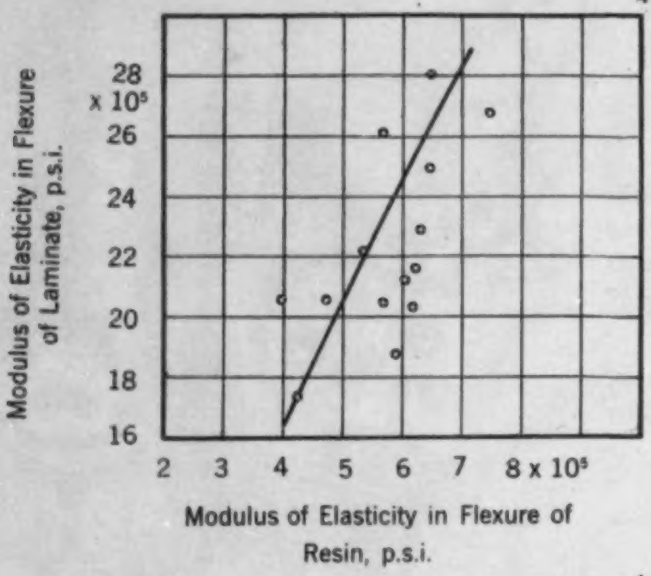

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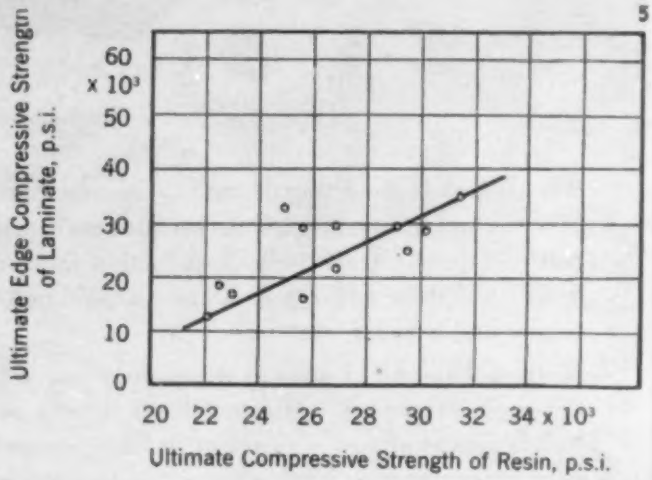

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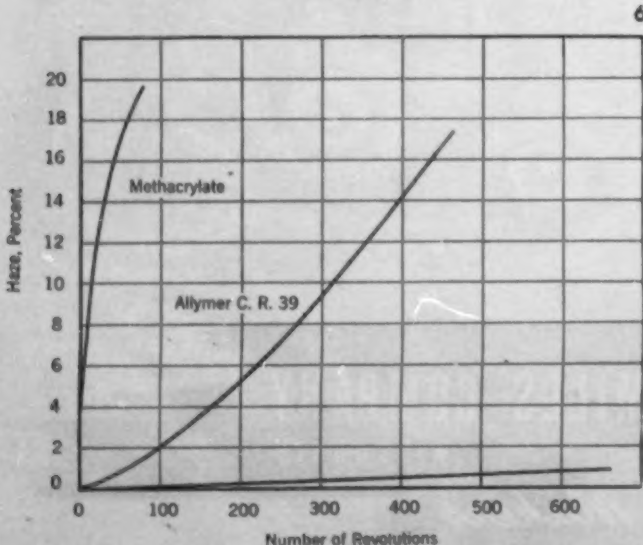

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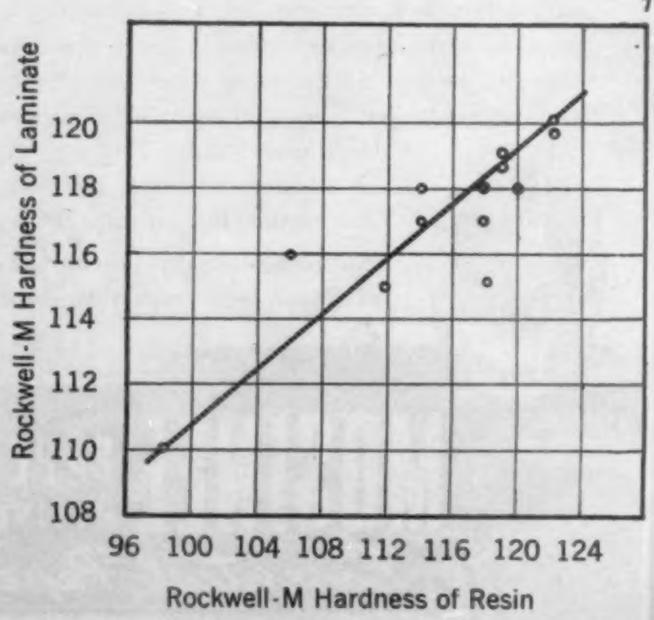

Polyethylene

(Continued from page 107) ventional blow-molding (Fig. 9) and swaging operations to produce containers that are form-stable in boiling water. Because of the inherent high ductility of polyethylene, it is believed that the cold-drawing operations normally used with soft metals will be applicable.

Heat-sealing and welding—The heat-sealing methods used to join Vinylite resin films can be used successfully in fabricating polyethylene film and sheeting. Again, the abrupt softening of these resins between relatively narrow temperature intervals makes care necessary in the selection of the temperature to use in sealing and in the method of sealing. Thin films protected with glassine paper can be sealed with a hot iron without serious difficulty. Massive shapes of the resin may be welded by the use of a low flame from a gas welding torch. Strong and attractive welds are possible. The molten resin will not ignite if care is exercised in the manipulation of the flame.

Cementing—Cements involving resins and volatile solvents are unsuitable for cementing polyethylene. Pressure-sensitive cements and hot-melts show merit, in initial trials, as seaming and bonding agents for sheets and films.

Machining and polishing—Polyethylene can be machined, drilled, carved and milled by standard machine tools. Sheets of polyethylene have a tendency to develop an objectionable static charge. Carbowax 1500 or aqueous solutions of Carbowax 4000 wiped on sheets and film with a damp cloth and briskly polished with a soft dry cloth, after the coating has dried, is effective in suppressing the static charge and produces an attractive high polish.

Solutions and emulsions—The solubility characteristics of polyethylene resins are unusual and extremely interesting. These resins are insoluble in all organic solvents at normal room temperatures. However, in agreement with thermodynamic concepts for crystalline materials, polyethylene begins to dissolve in a number of organic solvents at a temperature of 50 to 60° C. Figure 13 shows the solubility of polyethylene resin D-55 in carbon tetrachloride, toluene, xylene and trichloroethene, typical and effective solvents for polyethylene. The extreme temperature sensitivity of polyethylene solubility is shown in Fig. 13. Figure 14 is a phase diagram representing the solubility characteristics of polyethylene D-55 in xylene over a wide range of temperatures. Xylene solutions high in resin concentration gel under conditions set by resin concentration and temperature of system.

The properties of polyethylene and a recognition of the solubility characteristics of the resin make possible an application of this material to processes involving the following:

1. Film casting.
2. Surface coatings.
3. Impregnation and proofing of paper, cloth, wood, etc.
4. Emulsions. Polyethylene solutions may be emulsified to make stable aqueous dispersions with conventional emulsifying agents. The polyethylene emulsions have been suggested as useful for polishes, paper sizing, etc.
5. Hot-melts and "potting" compounds. Solid solutions of polyethylene and other hydrocarbon waxes and resins may be formulated.
6. Modifying agents for natural and synthetic rubbers. Polyethylene is an effective processing aid and modifying agent for GR-S synthetic rubber.

Present and future applications

The extremely good electrical properties of polyethylene assures the resin a permanent place in the insulation field. The other unusual characteristics of polyethylene warrant

Table III.—Properties of Polyethylene Resin at Room Temperature

Properties	GRADE DESIGNATION OF POLYETHYLENE RESINS *D-40*	*D-55 (DYNH)*	*D-70*	*D-85*	*D-100*	*D-130*	*D-145*	*Test method*
Molecular weight, average	14–18,000	18–20,000	20–22,000	24–26,000	26–28,000	28–30,000	30–32,000	...
Specific gravity	0.92	0.92	0.92	0.92	0.92	0.92	0.92	...
Stiffness in flexures, p.s.i.								
25° C.	18,000	18,000	18,000	18,000	18,000	18,000	18,000	ASTM D747–43T
0° C.	30,000	30,000	30,000	30,000	30,000	30,000	30,000	ASTM D747–43T
−25° C.	66,000	66,000	66,000	66,000	66,000	66,000	66,000	ASTM D747 (Tentative)
−50° C.	160,000	160,000	160,000	160,000	160,000	160,000	160,000	ASTM D747 (Tentative)
Yield strength, at 25° C., p.s.i.	1,430	1,480	1,490	1,600	1,700	1,830	1,720	ASTM D412–41
Tensile strength, p.s.i.	1,430	1,825	1,965	2,435	2,965	3,160	3,060	ASTM D412–41
Compressive strength, p.s.i.	...	3,000	...	...	...	...	...	...
Ultimate elongation, at 25° C., percent	305	560	550	560	580	605	625	ASTM D412–41
Brittle temperature, ° C.	−55	Below −70	Below −70	Below −70	Below −70	Below −70	Below −70	ASTM D746–43T
Impact strength, ft.-lb./in. of notch	...	>3	...	...	...	...	...	ASTM D256–43T (A)
T_F/° C.	...	−40	...	...	...	...	...	WC-72B
Tear strength, p.s.i.	440	500	540	560	580	605	690	ASTM D624–41T
Abrasion volume loss (standard B rubber = 100)	85	55	50	45	40	35	30	[a]
Hardness								
Durometer D at 25° C.	52–54	52–54	52–54	52–54	52–54	52–54	52–54	...
Flammability	Slow burning→						...	ASTM D568–41T
Solubility	Not soluble in all common solvents at temperatures below 50–60° C. Soluble in chlorinated solvents, aliphatic hydrocarbons and aromatic hydrocarbons at elevated temperatures						...	...

[a] Test described by Duggan, F. W., "Abrasion Resistance of Flexible Vinyl Plastics," Product Engineering *14*, 44–9 (Jan. 1943).

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consideration of this material for many applications entirely unrelated to electrical uses. As an example, injection molded polyethylene washers for cylinder valve packing (Fig. 16) are now outperforming the rubber gaskets previously used.

A list of suggested applications, based on the properties of polyethylene, are given in the following outline. No attempt has been made to weigh the economies of these suggested applications.

Electrical applications

1. Low loss cables (communications, radio, F.M. Television, etc.)
2. Condenser dielectric
3. Coil lacquer—insulating lacquers
4. Radio equipment, coil forms, spacers, sockets, etc.
5. Radio spaghetti tubing
6. Cable conduits
7. Submarine cables (replacements for gutta-percha)
8. Power cables

Applications involving chemical resistance

1. Semi-rigid piping and solvent hose lining
2. Beverage tubing
3. Tank linings for corrosive liquids
4. Shatterpoof reagent bottles and medical ampoules
5. Bottle closures and liners
6. Gaskets, diaphragms, packing, stoppers
7. Solvent and oil-resistant floor covering (probably as impregnated fiber)
8. Impact-resistant battery jars
9. Acid buckets, funnels, etc.

Medical applications

1 Sutures
2. Catheters
3. Probing wire insulation
4. Ampoules

Molded and extruded products

1. Automobile hardware, steering wheels, etc.
2. Knife handles
3. Refrigerator trays and parts
4. Hammer or mallet heads
5. Business machine keys
6. Canteens
7. Tumblers, dishes—light unbreakable picnic-ware
8. Eye shades
9. Flashlights (oil and impact-resistant type), cases
10. Buttons, buckles, etc.
11. Fish lures
12. Wearing apparel accessories
13. Children's toys (safe); blown and swaged articles
14. Grommets
15. Marine bearings—propeller shaft
16. Connections for gas meters
17. Dresser rings
18. Extruded trim
19. Collapsible tubes

Packaging

1. Food packaging—as cast film
2. Food packaging—as coated paper
3. Closures, liners, etc.

Applications involving fibers or monofilaments

1. Screens
2. Filter cloth
3. Spun fibers for fabrics, Figure 15

Impregnated cloth

1. Acid and solvent-resistant clothing
2. Gloves for resistance to oils and corrosive agents
3. Belting for use in contact with oils and solvents
4. Conveyor belts in food and meat packing industry

Lighting applications

1. Diffusing screens in fixtures, lamp shades, etc.
2. Skylight windows
3. Neon sign tubing
4. Bus and train window shades

Unclassified applications

1. Casters and pulley facings
2. Inert medium for standard colors (pigments, lakes and oil soluble dyes)
3. Addition agent to paraffin
   a. Heat resistant candles
   b. Where increased strength and heat resistance are required, such as for buffing compounds (polishing pastes)
   c. Wax dummies and models
4. Addition agents to beeswax, carnauba wax and other vegetable waxes
5. Paper sizing
6. Cloth sizing
7. Shoe tipping
8. Floor tile
9. Addition agent to bitumen and shellac for molded sound records
10. Statuary and sculpturing material
11. Printing plates
12. Processing aid and modifying agent for natural and synthetic (GR-S, GR-I) rubber

An emergency measure

(Continued from page 96) barges and pontoons may see service in almost any combat zone. In the case of the flexible hose that connects the pump with the rubber casing of the boat, cellulose acetate butyrate is used for the inner spiral coil. The spiral is made so that it will expand on the inside of the braid-covered rubber tubing and thereby stiffen the hose. This construction prevents the hose from kinking—a condition that would impede the satisfactory operation of the pump and might even stop the passage of air entirely.

In the forming of the cylinder of this emergency inflation pump, the paper is first treated with a phenolic-type resin and then wound convolutely on a special tubing machine. Since the entire pump involves precision work, the resulting cylinder is machined on the outside to achieve the concentricity and tolerance necessary to permit the tubing to fit inside the two end caps.

Both the top and bottom caps on this pump are compression molded of high-impact canvas-type phenolic material in 12-cavity mold equipment. A 3-min. molding cycle is employed. To insure the easy and satisfactory operation of the pump, the inside diameter of the caps must be maintained within fairly

close tolerances. In the case of the top cap through which the plunger handle operates, even a fairly slight variation in size will throw the plunger shaft off center and impede its action. The bottom cap is permanently assembled to the pump cylinder with a phenol-formaldehyde resin adhesive that is subsequently cured in an oven. In contrast, the top cover of the tube is fastened in place by three self-tapping screws. This arrangement makes field repairs possible.

A valve disk, $4^1/_8$ in. in diameter by $^3/_{32}$ in. thick, is another part of this inflation pump that is made of a paper-base phenolic laminate. All the other internal parts of the unit are still made of metal. It was felt that the plastic housing would tend to guard them against corrosion. Consequently, a change of material was not necessary.

In the final assembly operation, the braid-covered rubber hose with its extruded plastic inner coil is locked in place with the same resin adhesive used to cement the bottom cap to the body of the pump.

While our recent landings in France should reduce the need for our airmen making over-water flights in the European theatre of war, the war in the Pacific is another matter. And more landings may be in prospect along the coast of France and Norway. In any case these inflation pumps stand ready to meet the double emergency of a forced landing and the failure of the supply of CO_2 gas.

Credits—Material: Caps and cylinder, molded and laminated Insurok. Coil, Tenite II. Resin adhesive, Evertite FD-3. Molded by The Richardson Co. for Peters and Russell, Inc. Hose by Detroit Macoid Corp.

New flash lathe

(*Continued from page 116*) that is best adjusted to a particular diameter or weight of work. This feature is of importance since the spindles, which are capable of revolving at a speed as high as 2400 r.p.m., should turn at a high r.p.m. when small diameter pieces are being finished. They should be slowed down, however, for parts with large diameters. Furthermore, variation in the speed of the feed drive eases the task of loading a variety of sizes.

The four flash removal stations, or tool posts, are designed for maximum flexibility. The loosening of the taper nut (G) permits the tool post to be adjusted up and down and on an arc, while a few turns on this same nut will lock the post securely in any position. Since actual practice has shown that it is seldom necessary to have more than two stations for the removal of a single flash, the third and fourth stations can be used for an additional finishing operation or for the buffing of the flash mark so that it blends with the adjoining surfaces.

Tool posts (three of which are shown at C, E and F in Fig. 3) can carry either a file, abrasive strip, cutter or buffing strip—depending upon the location of the working area. A buffing pad is attached to tool post E, and a file is shown in place on post F. This file is adjusted to bear on the top of the plastic part to remove, in the case of the fuze caps, a slight flash directly above the threads. In the finishing work on the fuze, the first file on the machine is set at a different angle for another finishing operation.

Extreme care has been taken in the design and construction of the work stations so that they can be closely adjusted. The slotted tool post casting (I) permits the tool posts to be moved to different points around the circumference of the work table. By this means a close control can be maintained over the amount of material removed during the finishing operations. The uniformity of the flash removal marks on the plastic parts processed by this machine (Fig. 1) demonstrate the accuracy and versatility of this machine.

The ease of loading and unloading rests on the construction of the cam (B), which is shaped to retract the top spindles when the parts are to be ejected or loaded. The gradual curve of this cam allows the top spindle to make contact with the piece as soon as it is in place on the bottom spindle and to hold the part in a firm grip until the finishing operations are completed. At this point (O) the revolving spindles are stopped and the top spindle begins to rise as the shoe starts to ride over the top cam. The loading zone on this lathe extends from the points marked M and N in Fig. 2.

These units can be powered with either a 220–44–, 3-phase, 60-cycle motor or a 110–220 volt, single-phase 60-cycle motor. The design of the lathe, now available in a bench model or a floor model, makes adjustments easy and eliminates the need for skilled operators.

Credits—Machine: Manufactured by J. M. Nash Co. Developed in cooperation with Eclipse Moulded Products Co., where the first unit is now in operation.

High-frequency molding

(*Continued from page 115*) show less than 0.2 per cent moisture after being submerged in water at 25° C. for 24 hours.

Before the installation of this high-frequency equipment the rejects on the distributor heads often ran as high as 30 to 50 percent of the day's output. With asbestos-filled melamine priced at 52 cents a pound, this type of molding was unprofitable. However, once high frequency was adopted for the heating of the preforms, the percentage of rejects dropped below 5 percent. Often there is no spoilage in an entire day's production.

The complete cycle for molding one of these heads is 12 minutes. With an allowance of time out for lunch and two short recess periods, production now stands at 35 heads per press in an 8-hr. shift. Production prior to installation of the new unit was less than half this amount. With the plant operating on three shifts, the current output of perfect heads from the two presses far exceeds the company's expectations.

Credits—Material: Melmac. Molded by Diemolding Corp. for Bendix Aviation Corp. Thermex high-frequency equipment by Girdler Corp.

6—After 3 min. of mold closing and 5 min. of setting up, the finished distributor head is removed from the mold

PHOTO, COURTESY THE GIRDLER CORP.

Shatter-resistant glazing

(*Continued from page 88*) of dry ice and alcohol (C). The semi-cylinders were $17^1/_4$ in. long by 22 in. in diameter. A quick-action trip mechanism facilitated the lowering of the dry ice-alcohol pan which permitted immediate shooting at the pressurized plastic semi-cylinder. The results of bullet penetration on the pressurized semi-cylinder are shown in Figs. 9, 10 and 11.

Properties of the laminate

The problem of collecting data which can be used to design pressurized transparent plastic airplane enclosures is complicated by the fact that mechanical properties are generally determined by testing machines which employ rapid loading. Values of tensile and flexural strength obtained in this manner cannot be used with confidence in the design of structural members because plastics undergo cold flow dependent upon the amount and duration of the stress. These factors are exemplified in Table II which shows the properties of the laminate and unilaminar methyl methacrylate sheets. Temperature is another factor which influences the mechanical properties of thermoplastic materials.

The values of tensile and flexural strength in long-time tension and flexural creep tests permits the establishment of safety factors in structures which are stressed for comparatively long periods.

The presentation of a comprehensive summary of mechanical properties of this type of laminated sheeting is further complicated by the fact that it is a non-isotropic material made up of outerlayers of rigid methyl methacrylate and interlayers of flexible polyvinyl butyral sheeting. It is obvious that a variation in the ratio of thickness between outerlayer and interlayer will make a pronounced difference in the physical properties. Also, the direction in which a load is applied, e.g., perpendicular or parallel to the laminae in the case of flexural and impact samples, influences the values that are obtained.

The sheeting possesses self-sealing tendencies above 0° F., that is, a hole caused by the penetration of a bullet through it tends to close up. When it is penetrated at lower temperatures, the hole is small and area of fracture is limited.

Credit—Material: Laminated "Lucite-Butacite" sheeting

Field x-ray unit

(*Continued from page 92*)

Figure 6 shows three parts used together but made of different materials. The supporting bracket (the small piece with the molded ring set at right angles) is made from fabric-base high-impact phenolic material. The split ring portion of this piece supports the cathode end of the x-ray tube, and must therefore not only possess requisite electrical properties but also retain its dimensional stability under the operating heat of the tube. The ring is split to allow the plastic to adjust itself to the dimensions of the tube as it expands and contracts in use. The plastic, which is strong yet has the necessary spring to support the tube under all temperature conditions, provides a tube support virtually impossible to design from other materials.

The second and largest part (illustrated in Fig. 6 and also clearly seen in place in Fig. 3) is the high voltage lead-in socket. Because the high voltages used in the apparatus generate considerable heat, the socket must resist all operating temperatures of the unit which, under constant use, rise to well over 200° F. This part could perhaps have been machined from laminated tubing, but the process would have been slower than molding. In addition, the variety of properties resulting from the use of several materials molded into the piece could not have been attained. The increased strength of the molded thread as opposed to a cut thread, coupled with the fact that the part must be leak-proof, made the material and production method selected ideal for the application. This socket or tube is molded of three different types of phenolic material through the use of "offset" molding process.

The interior of the dark end of the tube is composed of medium low-impact material. The exterior of the dark portion is medium impact. The lighter part of the tube is mica-filled low-loss material. Preforms containing the medium low- and medium-impact materials are placed in the core, heated and partially formed by a breathing action imparted to the mold which causes the core to force the preforms into place. Then, as the mold finally closes, the balance of the material is introduced from the offset or land portion of the mold. Fuzing with the softened preforms, it forms the complete socket.

To prevent the connecting plug from being pulled prematurely sideways, a tough phenolic-paper laminated tube is inserted in the socket after molding. This piece can also be seen in Fig. 6, removed from the socket for purposes of illustration.

Figure 7 shows the housing which carries the measuring scale for focusing the unit. This housing is injection molded of polystyrene and requires no finishing or machining operations. The injection-molded tip of the scale is of cellulose acetate and must be tough to withstand the riveting operation by which it is fastened to the scale.

Cast phenolic resin in stock sizes is used to form a filler ring (shown in Fig. 3 as the first projection above the end caps). This ring is merely a trim ring used in place of a bracket when the x-ray tube is mounted by different means. This part is subject to high operating temperatures, but strength is not a paramount feature.

Not illustrated is a temperature-indicating button on the end of the cap. This button is molded from urea molding material and is red in color. The function of the button is to allow the cooling oil to expand and contract by forcing the button in and out as the temperature of the oil varies. On certain models this button will snap out of position if the operating temperature of the oil exceeds safe limits.

Not only the single knob shown in Fig. 3 but also the numerous standard knobs used on the control panels of the apparatus are molded of general-purpose phenolic molding material. These knobs are light in weight and require no finishing. They are also easily cleaned in operation—resisting all disinfectants. They can be molded onto the shafts or firmly fastened by set screws.

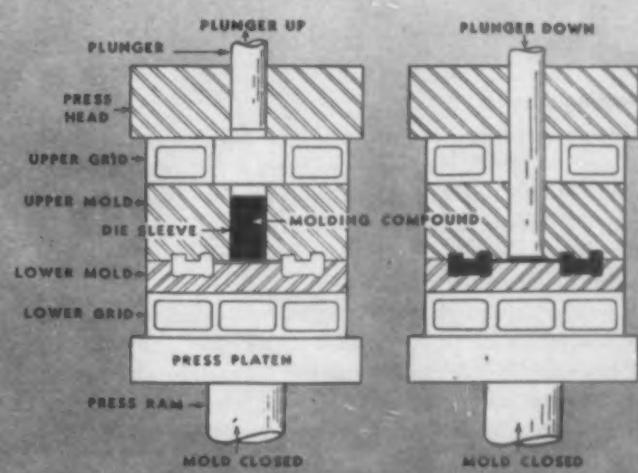
This glimpse into an engineering department's analysis of the various types of plastics and their application will certainly give pause to engineers who are expecting miracles from "a" material called "plastics." The part of the molder should not be overlooked. He, too, offered many suggestions and materially aided Picker engineers in gaining the necessary information about the many types of plastic now available as integral engineering materials.

Credits—Material: Bakelite, Bakelite Polystyrene, Plaskon, Synthane, Tenite. Molded by Recto Molded Products, Inc., for Picker X-Ray Corp.

H·P·M BUILDS THE PRESSES FOR WESTERN ELECTRIC'S *Duplex Molding Process*

Ever striving to perfect a better method of molding intricate thermo-setting plastic parts for telephone and allied equipment, Western Electric engineers developed the "Duplex Process." The impressive installation of self-contained H-P-M molding presses illustrated below is the direct result of collaboration between H-P-M and Western Electric engineers. Each press employs the "Duplex Process." Regardless of your plastics molding requirements, whether presses of standard or special design are required, H-P-M welcomes the opportunity of serving you. As a pioneer builder of plastics molding machinery, you will find our experience a valuable asset.

Duplex molding—The mold is closed and clamped by the upward acting ram. A center opening in the upper grid permits the operator to drop molding material into the die sleeve. A downward acting plunger forces the material into the mold cavities.



Self-contained H-P-M molding presses installed in the Kearny plant of Western Electric Company.

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Infrared heating

(*Continued from page 111*) ing after drying, are somewhat hygroscopic under certain climatic conditions. Quite often the heat put into the material is lost before it reaches the feed cylinder. Sometimes, during this cooling, moisture is adsorbed from the air by the plastic granules. A hopper heater, adjustable as to height over the hopper, mitigates this difficulty and tends to insure consistent results from drying. This heater should have some type of lamp control to prevent overheating and caking, and be easy to remove and install. A standard inexpensive commercial hopper heater (Fig. 2) incorporating these features and designed to replace the many types of home-made units now observed in molding shops has just made its appearance. A mirror has been placed under the unit to show how the heat lamps are arranged at angles in the reflector so as to cover the widest area and heat the sides of the hopper when the material level gets low.

Preheating plastics

In contrast to drying, preheating of plastics attempts to speed up the molding process or increase the capacity of a machine by heating the material before it goes into the heater. By virtue of this type of heating the efficiency of the plunger is not wasted in forcing dry, cold powder through the heater restrictions. Preheating alone, however, is not always sufficient to increase the output of a molding machine. The bulk factor of the unmolded material is such that in most cases the feed cylinder cannot accommodate an increase in the amount of material. However, when preheating is applied, the required injection pressure is slightly reduced and the machine functions more evenly and efficiently.

In injection molding, the best results are derived from preheating when a larger size plunger and feed cylinder are installed to permit more material to be fed into the heater. Generally this practice appears to be most useful when limited to the molding of heavy or thick sections. In such cases the clamping pressure of the machine is not so likely to be overtaxed as when the projected area of the molded part is increased.

The problem of when to use preheating generally resolves itself into a question of whether the section to be molded is heavy enough to require additional plastifying capacity and/or a slightly larger feed cylinder in order to fill the mold effectively. Some materials, such as the acrylics, seem to be "high-pressure" materials and it is not always possible to drop the molding pressure without getting sink marks or bubbles. Other materials such as polyvinylidine chloride and nylon seem to lend themselves to lower pressures.

The installation of an insulated hopper of the type now being made available on some standard machines is sometimes recommended for use in preheating. When temperatures are employed that approximate those at which caking occurs, an indicating pyrometer is suggested as a means of warning when the danger point is approached.

Problems such as bulk factor, caking, chemical changes and the problem of handling hot, sticky materials in the feed mechanisms of injection machines place definite restrictions on the use of preheating. The caking point, which occurs before fusion, also varies with the hardness of the plastic, the type of plasticizer used and the length of the time at which the material is held at elevated temperature. Some materials become tacky at 150°F.; others can be carried up to 275° F. or higher with safety. The use of a vibrator mounted on a hopper will help prevent caking in the hopper and is sometimes recommended where maximum preheating is desired—especially for the softer materials which tend to bridge in the hopper. However, while infrared preheating is useful in helping to mold certain materials in certain shapes, it is doubtful if it can be justified for installation on every molding machine merely to increase capacity.

When the infrared drier is used for preheating, it is best to mount the unit so that, if possible, it will discharge the material directly into the machine hopper. The vibrator and lamp controls are then mounted at the operator's fingertips. If desired, provision can also be made to place an entire drum of material so that it feeds directly into the preheater hopper. Figure 3 shows a new mounting of the drier whereby it is installed over the machine hopper with integral supports resting directly on the floor. This arrangement prevents the vibration of the injection machines from disturbing the even flow of material through the drier.

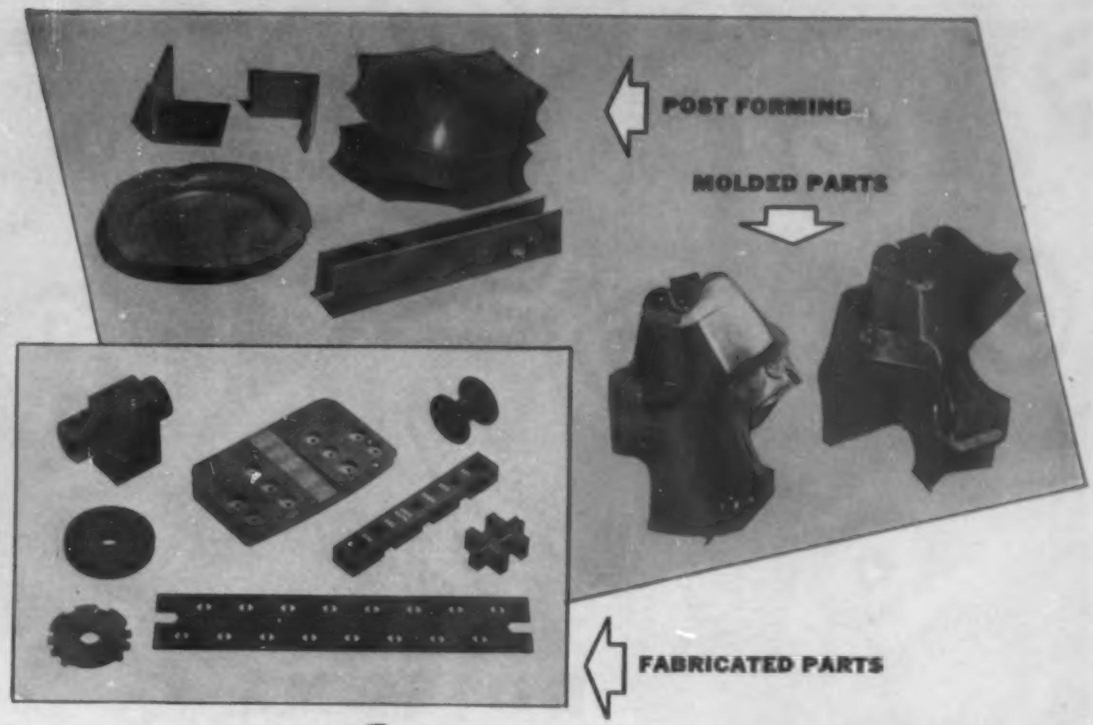
To accommodate the variety of conditions prevailing at all times on different molds using different powders, the use of one drier-preheater with each molding machine is recommended. This practice reduces the manifest danger of contamination resulting from the use of a compartment-type drier when several streams of material are fed through the same drier and then carried via pipes to different machines.

Another type of infrared preheater (Fig. 4) is a plate-type heater for softening sheet, rod or tube plastics before forming. Infrared has proved itself to be very useful in the forming field. Where extruder feed strips are to be preheated, infrared heat applied to both sides has been found to speed the process. In the preheater shown in Fig. 5, two lamp units are mounted in opposed positions. The material is fed into one end of the unit on expanded metal screen trays. The arrangement is such that when a fresh tray is inserted on the rack, the trays previously placed in the unit are pushed forward, directly under the heating elements. When the unit is used to feed an extruder, rolls are provided to draw the material past the lamps.

Other uses of infrared in the molding plant

At the present state in the development of plastic materials we often encounter a post-molding shrinkage which continues at a marked rate for 24 hr. or more after molding and then becomes imperceptible. This condition applies to elastomeric compounds such as the vinyls and copolymers of vinyl chloride and vinyl acetate, or vinyl chloride and polyvinylidene chloride. Some attempts are being made to accelerate and control normal post-molding shrinkages by annealing the molded piece under infrared lamps. Units similar to the one shown in Fig. 4, which was designed to soften sheet plastic for forming, are employed for this work. Accelerated aging by alternate subjection to wet and dry atmospheres, using infrared heat, is also being tried in an effort to "season" a plastic part in order to ensure stability under all conditions of use. To stabilize the plastic parts against gradual dimensional changes, especially where inserted metal parts are present and where post-molding changes might cause destructive cracking, relatively quick removal of volatile plasticizer is being sought by the use of infrared heat. Infrared heat is also being used to equalize cooling strains where a gradual cooling is required to prevent unequal stresses being set up which may later lead to cracks along the weld line. The use of infrared driers to speed the setting of cemented parts is not unknown and the practice sometimes saves the manufacture of extra holding fixtures. This type of heat can also be used to preheat injection molded parts for forming or bending operations when additional forming takes place subsequent to molding.

COMPREG



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The immediate demand will be for products that have acceptance—in all probability the old standbys of your pre-war product line with new improvements to be sure—products you know will give customers satisfaction—products that will give you low selling cost, low service cost with quick turnover and profits.

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Get into production on essentially those products you've sold or made before—improve, but be careful of radical changes.

Bring along those revolutionary new developments as quickly as they can be "proved."

It is wise to remember that products that are "coming" ring no bell including the one on the cash register, until they arrive. The products you made and sold in the past gave mighty good customer satisfaction and performance. To help meet the immediate postwar demand, what would be more sensible than to offer your customers and prospects good, proven products—*fast!*

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Since industrial progress has always been evolutionary . . . *never revolutionary*, it is only to be expected that the experience you have gained in working to military requirements of precision will have a permanent effect on your postwar product development and manufacturing methods. This is something to remember for when competition really becomes tough, the highest standards of quality will be imposed on every type of product—utmost production efficiency will be imperative for profitable operations.

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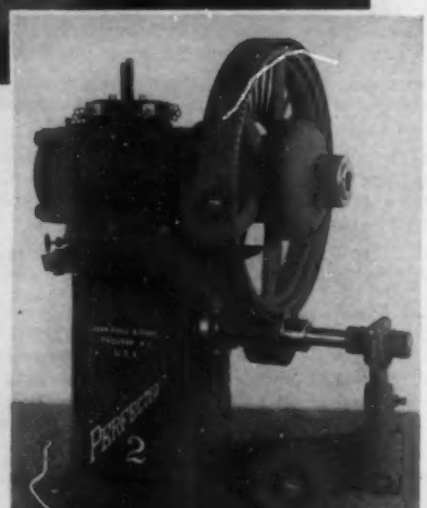

No. 2 Royle Tubing Machine of 1905

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Yes, it is being done. Not in one isolated plant but in many where ingenuity has been substituted for modern machines. These processors have done a grand job in literally interpreting "make it do."

Essentially the continuous extrusion process hasn't changed a great deal since John Royle & Sons first introduced it sixty-four years ago. There have been refinements—the most apparent being in the field of temperature control and in the development of accessory equipment.

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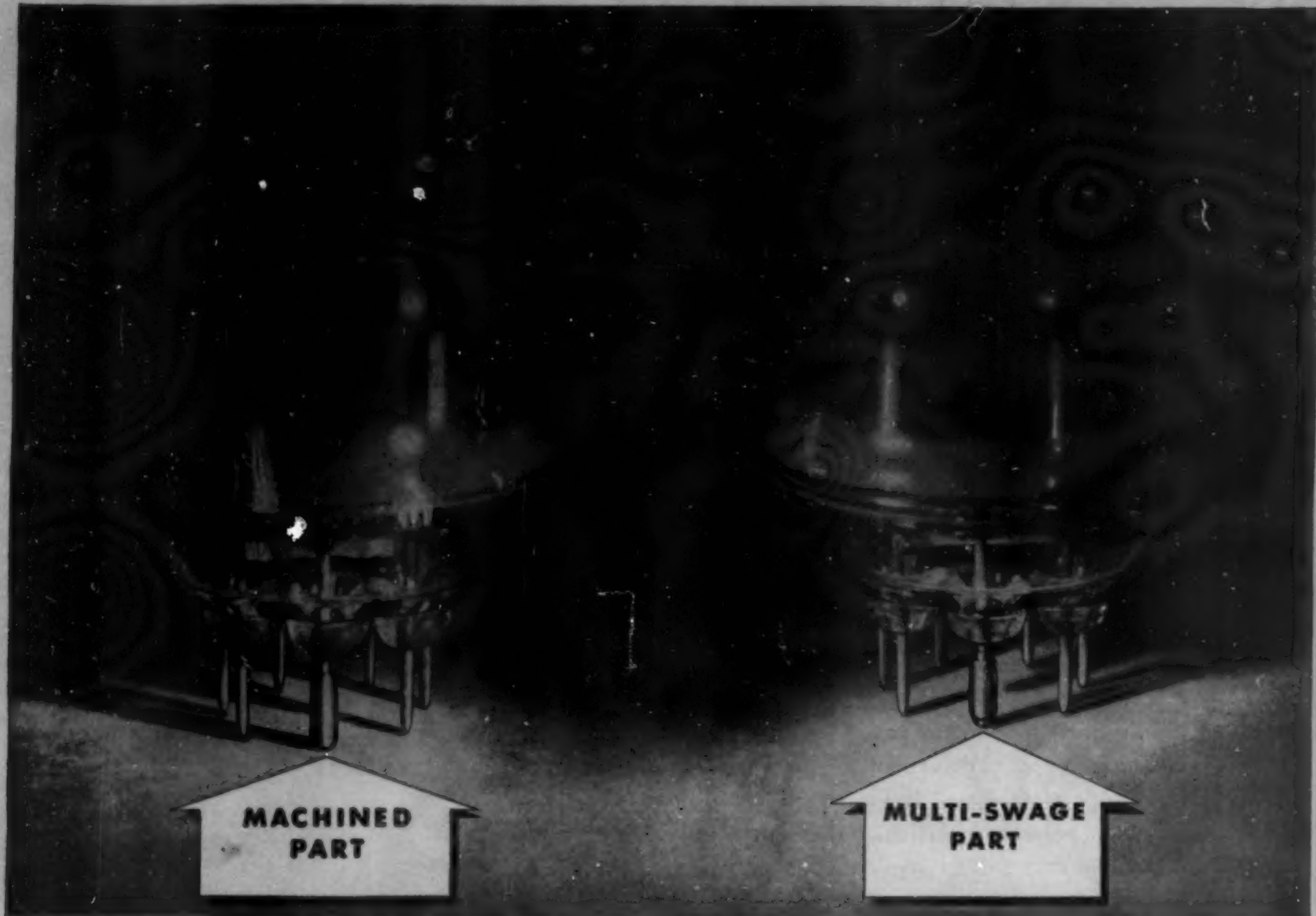

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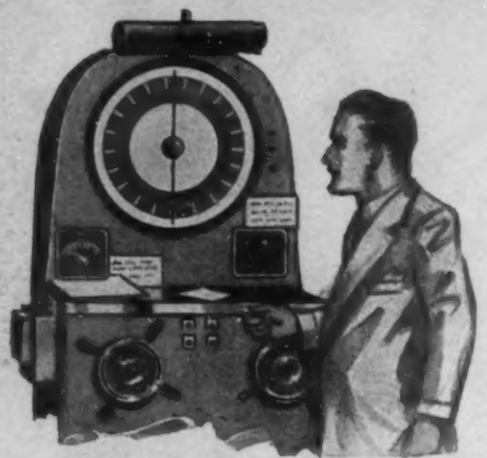

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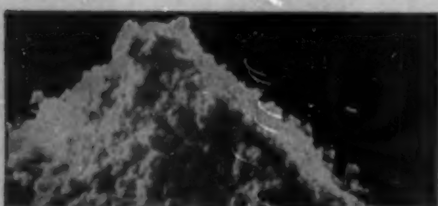

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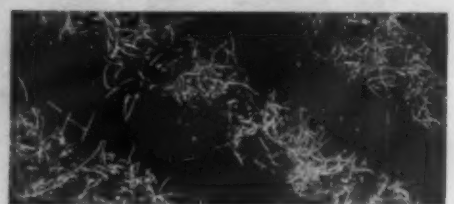

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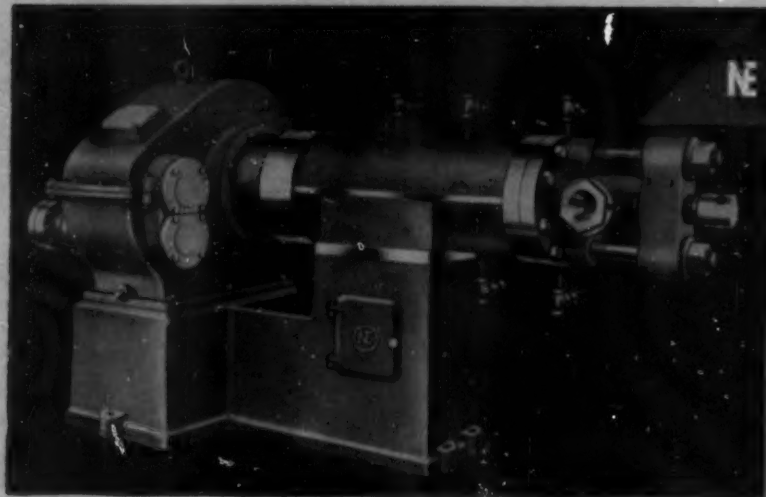


3½" NE Single Stage Extruder with two zones of heating

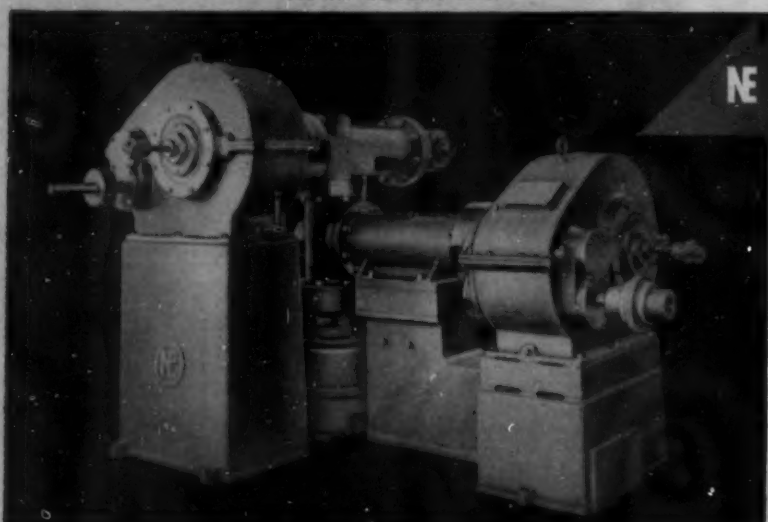
NE *Single* STAGE EXTRUDERS

are widely used where materials are readily plasticized. Illustrated is a 3½" Resin Extruder with special cylinder construction and two zones of controlled heating.

3½" NE Dual Stage Extruder features two stages of plasticizing and four heat control zones

NE *Dual* STAGE EXTRUDERS

were developed to meet special material characteristics. National Erie, as a pioneer builder of extrusion equipment for rubber products, has developed special extrusion machines for plastics users. The dual extruder illustrated is a very recent development.



4½" NE Triple Stage Extruder with five heat control zones

NE *Triple* STAGE EXTRUDERS

represent the very latest thought and design and are being developed to meet the most severe conditions of plasticizing. The triple stage extruder shown is used on vital war work and features a compact independent drive on each stage and progressive controlled heating.

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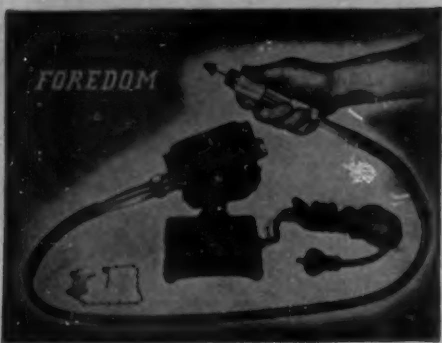
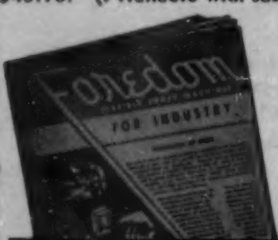
Are As Versatile and Adaptable As Plastics Themselves



Model illustrated is Foredom No. 340. Comes with either foot or hand-operated rheostat at $45.70. (Available with suspension-type motor. No. 240, at $43.20, including foot rheostat.) Other models as low as $23.50.



The finger-tip controlled Foredom gets into many places ordinarily inaccessible and does many jobs quickly and efficiently that otherwise require expensive, time-consuming hand labor. The versatility of Foredom Flexible Shaft Machines is matched only by the versatility of plastics themselves. Foredom's wide range of easily interchanged accessories and choice of four different handpieces, means that every Foredom Machine is ready at a moment's notice to rout, carve, trim, finish, mill, drill, slot, bore—or perform many other services in repairing and maintaining heavier equipment, touching up molds, or working on plastics themselves.

Finger-tip control . . . . plus a wide variety of accessories . . . . . means precision workmanship, unlimited adaptability.

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Finishing and touching up plastic molded parts

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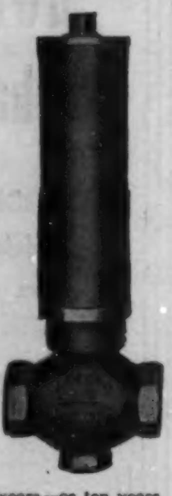

Briefly, it is a formed packing of special material superior to leather which is immune to all fluids commonly used in hydraulic machinery—water, oil, air, etc.

That is one of the reasons why this remarkable valve does so well at pressures up to and including 6,000 lb. per sq. in.—*positively without shock.*

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We didn't make this valve in one year—or five years—or ten years. It is the result of nearly a half century of experience exclusively in the regulating valve business. Hence its superiority. Its design is based on the latest and best principles as for example the packing described above. Every detail is up-to-date. Forged Steel Body. Internal metal parts entirely of stainless steel. The pressure on the seat is balanced by a piston with the result that variations in high initial pressure have little effect on the reduced pressure.

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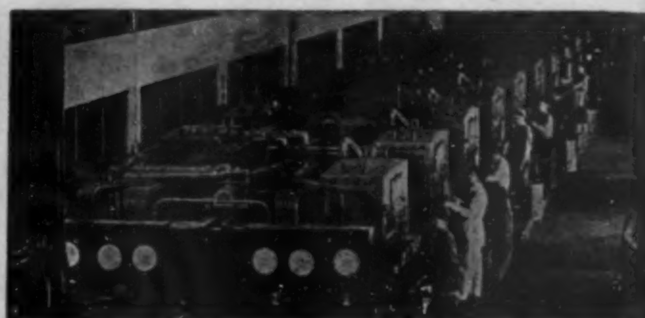

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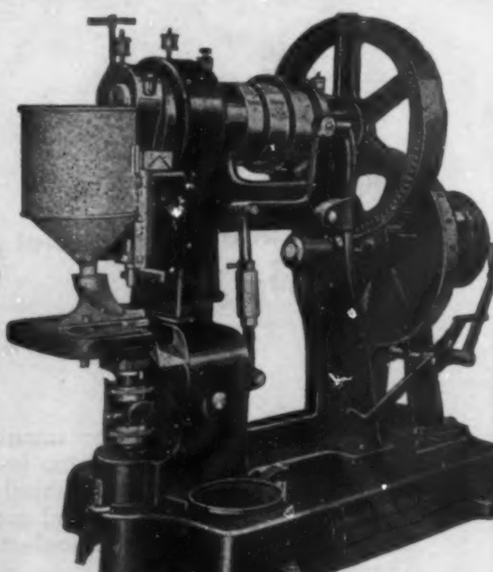

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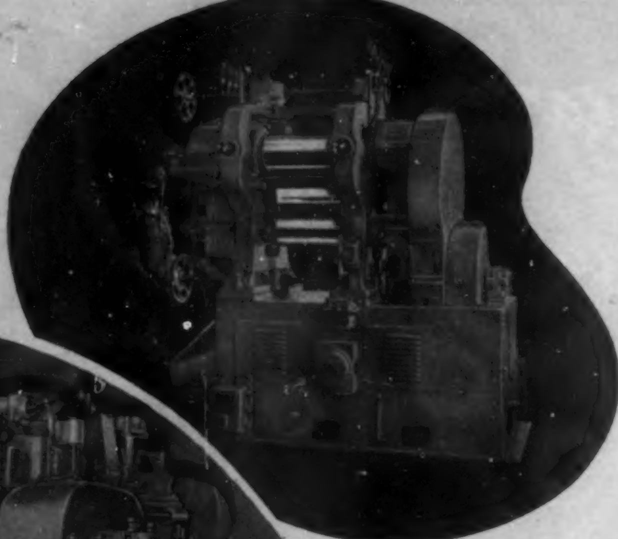

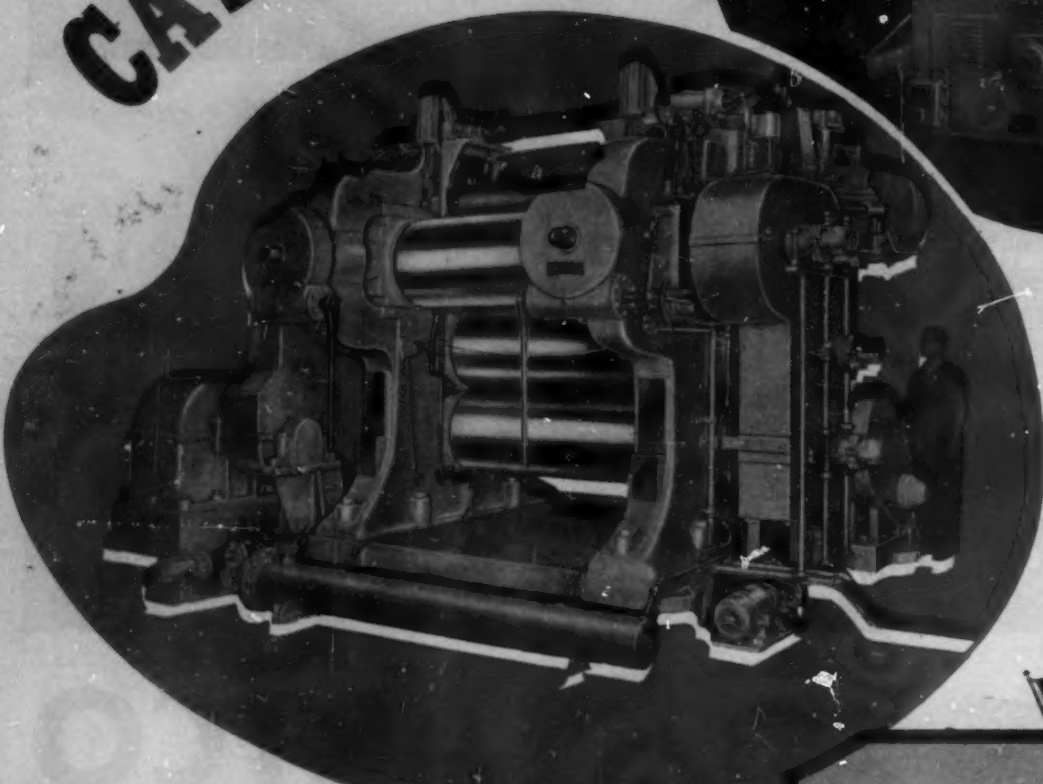

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Available for September delivery. A limited number of 12-Ton Hydraulic Laboratory Presses, 8 x 8 mold capacity, 6-inch stroke. Suitable for compression molding, testing, laminating, preforming, and general plastic applications. Price $150.00 F.O.B. Cleveland. Heating plates extra. Reply Box 1035, Modern Plastics.

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to take responsibility for chemical phases of design and manufacture in well-known, medium size radio parts plant. Principal work on "plastics" with some on surface finishes, corrosion inhibition and adhesives. Present work on very high priority war development and manufacturing projects. Post-war prospects excellent since we have no war inflated organization to deflate. Write qualifications, experience, draft status and availability to Eng. Dept., Jensen Radio Mfg. Co., 6601 S. Laramie Ave., Chicago 38, Ill.

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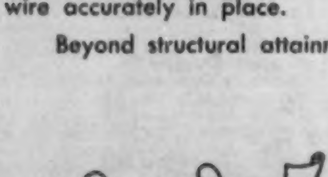

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